ENERGY MANAGEMENT PROGRAM FOR HOUSES

VOLUME 1

FIELD INVESTIGATION REPORT

TECHNICAL SUPPORT SERVICES BRANCH

Ontario Ministry of Housing

Technical Support Services Branch

ENERGY MANAGEMENT PROGRAM FOR HOUSES

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FIELD INVESTIGATION REPORT

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and its Agencies

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VOLUME 1 - FIELD INVESTIGATION

1.0 OBJECTIVE

The objective of the project was to produce an Energy Management Manual, suitable for use by Housing Authority Maintenance Supervisors in any one of the Ontario Housing Corporation (OHC) houses. This manual would be suitable for application to private sector housing usage as well. The purposes of the manual are:

1. To provide a method to identify houses which use more energy than an optimum that is based upon the specific house type and locale.
2. To define up to ten (10) energy conservation measures (ECM'S) based on a 0 to 3 year simple payback appropriate to the current status of OHC houses.
3. To provide Housing Authority (H.A.) Maintenance Supervisors with a reference manual as an aid to their operations.

Volume 1 - Field Investigation, is a report which deals with the field inspections and the testing which was performed, the results obtained and the evaluation of the data. Volume 2 is the Energy Management Manual consisting of a workplan and worksheets.

1.1 SUMMARY

This report documents the approach and methodology used in determining the Building Energy Performance Index (BEPI), Optimum Energy Usage (OEU) and Energy Targets for Ontario Housing Corporation (OHC) houses. Background on the project is provided, followed by an outline of the approach and procedure used in the determination of the BEPI, OEU and Energy Target. The results of the testing are presented followed by a discussion on the applicability of the North Niagara Housing Authority Energy Usage Monitoring System (EUMS) to the method.

The BEPI is a reference that expresses the total energy (fossil fuel and electricity) used by a building in a given year, i.e., kWh per gross conditioned square feet per year. The OEU is defined as the amount of energy that a given house uses for space heating given the house's "as is"construction, orientation, mechanical equipment and occupant behaviour. It identifies the minimum amount of energy that is required to heat a given house, without any upgrading, and is a good indicator of the influence of the occupants on the house energy use. The OEU was used to determine which houses use more energy than an optimum derived from the specific house type and locale. Although the OEU was based upon efficient energy use with

respect to space heating, the method does quantify DHW heating energy and electricity used for lighting, appliances etc. Further, the method used to establish the OEU incorporates an energy audit that identifies high energy using components of the house envelope, i.e., the walls, ceiling, windows, doors, and foundation wall, thereby assisting in the selection of appropriate ECM's.

Two Energy Targets were established; a BEPI Target reflecting the total energy consumption and an OEU Target reflecting the space heating energy consumption..

The actual energy use was defined as the energy consumption indicated by the fuel and electricity bills.

It was concluded that the method developed, in conjunction with the EUMS, will provide a sufficiently accurate means of monitoring energy consumption in OHC houses and will assist the regional housing authorities in the determination of applicable and effective energy conservation measures.

1.2 BACKGROUND

The Ontario Housing Corporation (OHC) currently owns approximately 22,300 houses located throughout Ontario. The majority of these houses are row houses, while the remainder are detached or semi-detached. Systems located in these houses were designed and installed according to the codes in effect at the time of construction. Space and DHW heating energy sources in descending order of frequency of usage are natural gas, electricity, furnace oil, propane and solar panels.

Given this large building stock, efficient energy management has become a priority. At the present time an energy management program (EMIS) is under development to enable housing authorities to identify high energy use projects and select cost effective energy conservation measures (ECM's). ECM's implemented by the housing authorities can then be evaluated after the fact using the EMIS system. The EUMS system is presently used by the North Niagara Housing Authority to monitor energy consumption.

1.3 APPROACH

(1) Assessment of the Existing Housing Stock

Seventy one houses were inspected throughout Ontario (see Appendix A for a complete listing of all the houses inspected) . Amongst the houses inspected there were 27 detached, 21 semi-detached, and 23 row houses. This differs slightly with the number of houses listed for inspection in the RFP (74) due to the inability to obtain access to several houses in South River and Mattawa.

In each category, the local housing authority selected houses whose energy consumption was high, average and low. The houses rated as high, average and low were not necessarily of the same design, i.e., not equal in volume, area etc. Energy bills from June 1987 to June 1988 for both electricity and natural gas were obtained for all the houses inspected.

The inspection consisted of a general appraisal of the houses with respect to the condition of the mechanical and electrical equipment and the building envelope. This included furnace and DHW combustion efficiency tests on gas fired equipment and a blower door test on 48 houses to ascertain the air tightness of the envelope.

In general, the blower door tests were limited to the detached and semi-detached houses with only one row housing complex tested. When the detached houses were tested, the standard blower door setup was used requiring one blower door. When the semi-detached units were tested, two blower doors were used simultaneously, one in each unit. This procedure ensured that an accurate leakage rate for the unit under inspection was determined since by depressurizing both units only air infiltrating from the outdoors, and not the adjoining unit, was measured. When a unit in a row housing complex was tested, three blower doors were used simultaneously. In this case a blower door was located in the units on both sides of the unit under inspection.

(2) Method Used in House Analysis

The following method was used to determine which houses use more energy than an optimum derived from the specific house type and locale. Although the method identified high users of electricity (other than for space or DHW heating), it focused primarily in identifying houses that were inefficient energy users with respect to space and DHW heating since:

i) Of the houses inspected 14 of the 71 used electricity as their only energy source

ii) The space heating and DHW heater accounted for 79% of the total energy used,

iii) In many cases the tenants pay for the electricity, while the Housing Authorities pay only for gas, and

iv) It is difficult to apply an ECM to control the use of electricity that is consumed for lighting, appliances etc.

The approach taken was as follows:

1. The actual energy usage of the house was determined. This was established by separately summing a year's gas and electricity bills for a selected house. The gas consumption was separated into space heating and DHW heating . The total energy consumption was the sum of gas plus electricity. The space heating gas consumption was used to isolate high energy users. See section 1.4(1) for further detail on the determination of the actual energy usage. Tables 1 - 6 depict the houses inspected, and their respective energy consumption.

2. The house was analyzed using HOT-2000, a microcomputer-based residential energy-analysis program developed by Energy Mines and Resources (EMR), to determine the amount of energy that was required to heat a house given its "as is" conditions. This was referred to as the house's Optimum Energy Usage (OEU). The purpose of the OEU was to:

i) Identify the houses which were performing as well as could be expected given the particular house construction, orientation, mechanical equipment and occupant lifestyle. This establishes that the house, without upgrading, is operating as efficiently as possible. It was assumed that a deviation of ± 15% between actual energy usage and the OEU constituted an agreement in values.

ii) Identify those houses that are inefficient energy users by comparing the OEU to the actual space heating energy consumption. It was determined that in the inefficient energy using houses the OEU was not attained due to an increase heat loss as result of air infiltration/ exfiltration or unusual

occupant behaviour e.g., a high thermostat set point . This conclusion was a result of the approach taken in the energy analysis of the houses (see section 1.4(2)). The increased air infiltration/exfiltration was either attributed to poor construction, as indicated by a high leakage rate measured during the blower door test, and/or to occupant lifestyle, i.e., opening of windows and doors.

3. An analysis of the HOT-2000 output was conducted to identify high energy using components of the building envelope i.e., ceiling, walls, windows, doors, foundation walls and basement floor.

Although HOT-2000 was used for the analysis, any comparable package, manual or otherwise, can be used provided that a breakdown of the losses through the envelope is provided and that the method is reasonably reliable. A manual procedure is presented in Volume 2, The Energy Management Manual.

1.4 PROCEDURE USED

(1) Determination of Building Energy Performance Index (BEPI)

The BEPI was determined as follows:

1. One years' gas and electricity bills for the houses inspected were obtained and separately summed.

2. Fuel factors were used to convert gas units into equivalent kiloWatts of energy (ekWh). This permitted the addition and comparison of electricity and fuel.

3. Total energy use of the house was determined by summing the ekWh for fuel and kWh for electricity. This represents the houses' total energy use, ekWh/year.

4. The BEPI was then determined by dividing the ekWh/year by the gross heated area of the house, ekWh/year/ft2

5. The two target BEPI's representing the two energy sources were determined by averaging the BEPI's of houses that had gas and electricity, and only electricity, as energy sources.

(2) Determination of Actual Space Heating Energy Usage

As the actual heating bills include the energy consumption of the DHW heater and for electrically heated homes, the energy consumed by lights and appliances, this energy was subtracted from the total so that the space heating component could be isolated. The energy supplied by the DHW heater was estimated by averaging energy usage through the summer months and extending it over the year. For electrically heated houses this value included electricity used for lighting, appliances, etc.

By separating the energy used for space heating from the energy used for DHW heating, an estimation was made in the contribution of the DHW heater to the total energy consumption. From this it could be determined if the DHW heater's consumption was excessive by comparing it's consumption to an expected average usage based upon published results, Reference (2).

(3) Determination of Optimum Energy Usage (OEU)

The determination of a house's OEU required that an energy audit be performed that took into consideration the "as is" house construction, orientation, mechanical equipment and occupant lifestyle. This required that the following information be known:

i) Heat loss through the house envelope

ii) Heat loss due to infiltration/exfiltration

iii) Heat gain due to solar gain, and

iv) Heat gain due to internal gains

The heat loss through the house envelope and the solar gains can be determined with confidence by performing a heat loss analysis. The heat loss attributable to infiltration/exfiltration, however, is difficult to estimate for any given house since it depends on such variables as house construction, wind induced pressures, stack pressures, pressures induced by air handling devices, and occupant lifestyle, i.e, opening of windows and doors. The internal gains are based upon occupant lifestyle, i.e., usage of appliances and DHW heater, number of occupants, and can only be accurately determined if such information is known.

The energy analysis was performed using HOT-2000. The inputs to the program were based upon the specific house and included:

i) weather data for the specific locale,

ii) house envelope data e.g., wall and ceiling construction, recorded during the inspections, and

iii) steady-state furnace and DHW heater combustion efficiencies for equipment fueled by natural gas as measured during the inspections.

iv) the thermostat set point was assumed to be kept at 21 C° (70 F°)

Adjustments to the program were as follows:

i) The internal gains were not calculated by the program from default values but were instead determined from actual occupant usage of electricity plus DHW heater standby losses (assumed to be 100 W). The heat gain due to lights and appliances was determined by summing the electrical bills and assuming that all this energy was transferred to the house as heat. It was also assumed that 8% of the fuel used by the DHW heater was given up as heat to the house. These assumptions are consistent with the calculation procedure used in HOT-2000. Occupant heat gain was assumed to be 0.065 kW and 0.033 kW per adult and child respectively, Reference (3).

ii) Air infiltration rates were based upon ASHRAE STANDARD 62-81, Reference (4). These air infiltration rates represent the minimum required to maintain air quality within the house.

The program output consisted of,

i) a breakdown of energy losses through the envelope, i.e., ceiling, walls, windows, doors, foundation walls and basement floor

ii) the seasonal furnace efficiency, and

iii) the solar gain

The net space heating energy usage for the house was then determined by summing energy losses resulting from heat loss through the building envelope and air infiltration and subtracting the internal and solar gains. The net energy usage was then divided by the seasonal furnace efficiency (determined by HOT-2000 from the inputted steady-state efficiency). This calculated energy usage was considered to be the OEU of the house given its unique construction and occupant characteristics.

(4) Comparison of Actual Energy Usage to Optimum Energy Usage (Space Heating)

If the OEU and the actual energy usage was within ±15% then the house had met its OEU. This meant that the house was performing as efficiently as possible given its particular house construction, orientation, mechanical equipment and occupant lifestyle.

A discrepancy between the OEU and the actual energy usage, assuming the actual is higher, was explained by a probable increase in heat loss due to either air infiltration/exfiltration or occupant behaviour, i.e., opening windows and/or doors, high thermostat set point. This is a valid assumption since the OEU air infiltration /exfiltration component and thermostat set point are the only variables that were based upon arbitrary inputs, that is the ASHRAE minimum and 21 C°.

Furthermore, it is now possible to identify high energy usage components of the building, i.e., ceiling, walls, windows, doors, foundation walls and basement floor, since energy use was apportioned to these components by HOT-2000. High energy using components can be identified by comparing the area of the component to the percentage that the component represents of the total envelope heat loss. If the area is small as compared to the percentage heat loss then an ECM may be required.

(5) Selection of Six Worst Energy Users

In order that all the houses could be compared, irrespective of size, energy use was normalized by taking the total energy consumed, the sum of gas and electricity, or electricity for electrically heated homes, and dividing this by the houses' heated floor area. The space heating energy was normalized by dividing the energy use by the houses' heated floor area and the number of degree days for the given area. Tables 1-6 presents all the houses inspected and their respective energy consumption. The selection of the worst energy users was based upon the space heating

energy consumption and the following criteria: (1) house type, (2) location and (3) energy source. The six houses selected are as follows:

	(1) House Type	(2) Location	Address	(3) Energy	Actual Space Heating Wh/DD/ft2	OEU Space Heating Wh/DD/ft2	Actual BEPI ekWh/ft2/yr	Target BEPI ekWh/ft2/yr
1.	D	Thunder Bay	517 Simon Fraser	NG & E	2.70	2.75	27.91	25
2.	D	Nipigon	165 Greenmantle	E	3.09	2.70	25.03	20
3.	SD	Listowel	907 Davidson	NG & E	3.76	2.32	25.89	25
4.	SD	Carelton Pl	334 Joseph	E	4.13	1.75	33.10	20
5.	R	Carelton Pl	144 Caldwell	NG & E	4.36	3.34	33.21	25
6.	R	Hamilton	32 Purnell	NG & E	7.59	2.76	56.40	25
					25.63	15.62	201.54	140

D - Detached SD - Semi - Detached R - Row House

An analysis of the six worst energy users was performed using HOT-2000. A complete breakdown of the results can be found in Tables 7 - 10.

1.5 EVALUATION OF DATA

(1) Steady State Combustion Analysis

The average steady-state combustion efficiencies for conventional furnaces and DHW heaters were 74.8% and 74.3% respectively, see Table 11. These values are in accordance with expected values for steady-state efficiencies of conventional furnaces and DHW heaters.

(2) Blower Door Tests

The blower door tests for all the houses inspected averaged 6.7 air changes per hour at a pressure differential of 50 Pa. Typical air leakage values range from 6 to 10 air changes per hour at 50 Pa. Reference (5). A complete list of the blower door air leakage values can be found in Table 11. See Tables 12 and 13 for a breakdown of air leakage rate vs house type.

(3) House Analysis

A summary of the house energy use and a complete breakdown of the energy losses through the various house envelope components of the six worst energy users are presented in Tables 7 to 10. An examination of the results follows:

1. 517 Simon Fraser — The OEU for this house was within 2% of the net actual energy use. Although the house used more energy than the other detached houses in Thunder Bay the house was in fact performing as well as could be expected. This means that the actual air infiltration component of the house is not excessive. This was confirmed by the blower door test result of 3.68 ac/h, well below the overall average of 6.7 ac/h. If the energy used for DHW heating, which is above the average use, is subtracted from the total gas consumed the house matches the other two similar houses. The combustion efficiency for the DHW heater was the average measured. Therefore, in this case the high energy usage is related to the DHW heating gas consumption and is an occupant related problem.

2. 165 Greenmantle — Although the space heating for this house was the highest of the three similar houses inspected, it's actual energy use was within 8% of it's OEU. In fact, of the three houses inspected the two highest were within the OEU range while the lowest energy user was 8% below it's OEU. Since the three houses were of similar construction it can be assumed that the difference between the three is occupant related.

3. 907 Davidson — This house used 62% more energy than the OEU while the other two identical semi-detached houses were within the OEU range. All three houses had comparable air leakage rates and DHW heating gas consumption. The increased energy usage could be attributed to occupant lifestyle. This may be an incorrect conclusion since the occupants reported that their thermostat was not functioning properly. This example illustrates the need to perform a complete house inspection before drawing conclusions as to the reasons for high energy use.

An analysis of the the envelope components indicates that the above-grade foundation walls represents 1.8% of the envelope area but 8.6% of the heat loss. This is a disproportionate amount and an appropriate ECM would be the insulating of this portion of the foundation wall.

4. 334 Joseph

This house used 135% more energy than its OEU while the other two similar semi-detached houses were within the OEU range. All three houses had similar electricity use for DHW heating and for lights and appliances. The house did have an above average air leakage rate of 7.26 ac/h but this alone cannot account for the more than double OEU. It can be concluded that the occupant behaviour could be responsible. In fact, this particular house was identified by the local Housing Authority Maintenance Supervisor as having tenants that were known to leave windows and the interior front door open during the winter. Therefore, the high use of energy was not a house related problem but an occupant related problem. This house is an example of high energy use that is strictly a occupant lifestyle related problem.

5. 144 Caldwell

This house used approximately 30% more energy that its OEU while the other two similar row houses were within the OEU range. All three houses had similar DHW heating gas consumption. Again the high energy use exhibited by this house was a result of the occupants lifestyle. The local Maintenance Supervisor has noticed windows and the interior front door open during the winter.

An analysis of the the envelope components indicates that the above-grade foundation walls represent 3.4% of the envelope area but 15.0.% of the heat loss. This is a disproportionate amount and an appropriate ECM would be the insulating of this portion of the foundation wall.

6. 32 Purnell

This house used 175% more energy than its OEU. The other two similar row houses were also higher than the OEU but by a significantly lesser amount. The house had both a high space heating and a DHW heating gas consumption. It can again be concluded that the high energy usage is an occupant related problem since no significant difference

exists in house construction between the three houses that could account for the large difference in energy use.

All three houses used more energy than their OEU. The furnace combustion efficiency test in all three homes averaged 67.0%, almost 8% less than the overall average. These furnaces were old and replacement may be necessary.

1.6 DISCUSSION

(1) Applicability of North Niagara Monitoring System (EUMS)

The procedure described above provides an accurate method of determining the optimum space heating and total energy usage of a given house or house type. Further, the method is capable of identifying various building components that are high energy users; from this appropriate ECM's can be selected.

This method could compliment the system presently in use by the North Niagara Housing Authority (EUMS) to monitor the energy consumption of houses. At the present time, the Housing Authority is using the system to monitor the energy usage of houses in the region. Houses whose energy usage is above a calculated mean for similar type houses are sent notices requesting that energy conserving techniques be used. Conversely houses below the mean are sent a congratulatory letter. This system as it stands has reduced fuel consumption by 6% and 3% during the first 2 years of operation, effectively returning the initial investment in the monitoring system. It should be noted that these reductions were solely due to the letter, suggesting that occupant behaviour was modified, a significant accomplishment.

The drawback associated with this system, however, is that the energy "target" values are established by calculating the mean energy usage of similar houses. The monitoring system used can only identify houses using more energy that the calculated mean, i.e., primarily occupant related differences. The mean, however, may not necessarily reflect the optimum energy usage or the energy target. For example, given conditions where a significant portion of the houses were high energy users then the mean would also be high. Furthermore, the system does not assist the Housing Authority in identifying any ECM's applicable to that particular house or house type since the system does not apportion the energy usage to the various building components. Essentially, the system is effective only as a monitoring tool.

The method described in Section 1.4 however, establishes an optimum energy usage based upon a heat loss analysis that takes into account the particular house and occupant characteristics. Using this method, in conjunction with the monitoring system developed by the North Niagara Housing Authority, high energy users can be identified and the sources of energy use can be established. From this, applicable cost effective ECM's can be selected and energy usage can be monitored to evaluate the upgrading.

1.7 CONCLUSIONS

The following conclusions resulted from the field inspections and analysis:

1. The method developed to determine energy targets for space heating (OEU) and total energy usage (BEPI) is a sufficiently accurate technique that can be used by the various Ontario regional housing authorities to identify (1) high energy using detached, semi-detached and row houses and (2) the applicability and effectiveness of energy conservation measures.

2. It became apparent during the field inspections and later the analysis of the six worst energy users, that a significant amount of energy loss was occupant related. In several cases Maintenance Supervisors described instances where windows and interior front doors were left open during the heating season. On three occasions the worst energy users in a region coincided with individuals who were identified by the Supervisors as leaving windows open during the winter. In order to control this type of energy loss an ECM that attempts to modify occupant lifestyle is required. The system developed by the North Niagara Housing Authority (EUMS) is recommended.

This system will also compliment the method developed since the EUMS establishes an energy usage database that can be used to monitor the implementation of ECMs as well as providing the energy data necessary for an energy audit.

3. Four of the six houses did not meet their OEU, (1) 907 Davidson, Listowel, (2) 334 Joseph, Carelton Place, (3) 144 Caldwell, Carelton Place and (4) 32 Purnell, Hamilton. Further, the high energy use in three of the four (907 Davidson was the exception) was occupant related. In two cases the local Maintenance Supervisors stated that the tenants left the windows and interior front doors open during the heating season (144 Caldwell and 334 Joseph). The tenants in the fourth house stated that their thermostat was not functioning properly (907 Davidson). This could be the source of the high energy use in this case.

4. Four of the six houses did not meet the target BEPI, (1) 165 Greenmantle, Nipigon, (2) 334 Joseph, Carelton Place, (3) 144 Caldwell, Carelton Place, and (4) 32 Purnell, Hamilton. Three of these houses also did not meet their OEU (165 Greenmantle was the exception) suggesting that the houses with a high space heating energy use will also have a BEPI above its target. This relationship is explained by the fact that space heating alone accounts for more than 50% of the total energy use in a house.

5. The general state of the houses inspected was good. Exceptions to this were found in Hamilton (Southern RHPO), Oshawa (Central RHPO) and London (Southwestern RHPO) where some of the houses inspected (pre 1950) did not have any wall insulation and the original windows were in very poor shape. In general, the condition of the houses were better in the smaller communities.

6. The general condition of the DHW heaters and furnaces was good with many of the houses having new furnaces. The average steady-state combustion efficiencies for conventional furnaces and DHW heaters were 74.8% and 74.3% respectively. These values are in accordance with expected values for steady-state efficiencies of conventional furnaces and DHW heaters.

7. The blower door tests for all the houses inspected averaged 6.7 air changes per hour (ac/h) at a pressure differential of 50 Pa. Typical air leakage values range from 6 to 10 air changes per hour at 50 Pa. The averages for houses with natural gas and electricity energy sources were 8.3 and 6.9 ac/h for detached and semi-detached houses respectively. The averages for houses with an electricity energy source were 4.9, 5.6, and 2.9 ac/h at 50 Pa. for detached, semi-detached and row houses respectively. The expected value for conventional detached houses is 5.0 ac/h at 50 Pa.

8. In general the houses inspected were poorly sealed and the majority of the tenants complained of drafty windows and doors. In most of these cases the windows were sashless double sliders and single pane vertical sliders, both poor quality windows with little resistance to air infiltration/exfiltration. Deterioration of the window frames, trim and interior finishes was found in these homes.

In many cases it was found that the dryer vent was left open to the exterior when no dryer was present. If the house had a attic hatch/access door, little or no weatherstripping was evident. In one case the attic access door was opened due to the depressurizing force exerted during the blower door test. The door opened at a pressure of approximately 15 Pa. (the average wind induced pressure differential is approximately 10 Pa.)

9. Of the houses inspected only 20% had insulated basement walls and header areas. These areas are responsible for a disproportionate amount of energy loss in comparison to their areas and should therefore be insulated.

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APPENDIX A

TABLE 1 - CENTRAL RHPO

CENTRAL RHPO

	LINDSAY	4512 Deg Day	
	DETACHED		
	124 KING	146 KING	154 KING
JUN	179.00	252.05	133.11
JUL	78.00	56.64	73.63
AUG	74.00	90.63	73.63
SEP	115.00	87.79	101.95
OCT	326.00	337.02	195.41
NOV	412.00	339.85	308.69
DEC	408.00	560.75	492.78
JAN	753.00	625.89	555.08
FEB	447.00	710.85	747.66
MAR	622.00	515.43	458.79
APR	284.00	529.60	399.32
MAY	193.00	155.76	155.76
ENERGY SOURCE	NG & E	NG & E	NG & E
TOT CONSUMP (m^3)	3891.00	4262.25	3695.84
TOT CONSUMP (ekWh)	36165.49	39616.12	34351.52
DHW GAS (ekWh)	9928.57	8740.90	9267.46
ELECT (kWh)	7369.35	9902.45	6497.00
HOUSE AREA ft^2	1400.00	1400.00	1400.00
TOTAL ENERGY kWh/ft^2	31.10	35.37	29.18
SPACE HEATING kWh/DD/ft^2	0.00415	0.00489	0.00397
ac/h at 50 PA	4.67	4.60	4.68
ELA - SQ IN	122.65	111.72	117.73

LEGEND - NG & E monthly values = m^3 gas, E monthly values = kWh
TOT CONSUMP = equivalent kiloWatt hours for NG & E energy source
ELA = equivalent leakage area, in^2
ac/h = air changes per hour
no. of degree days = average of 30 years

TABLE 1 - CENTRAL RHPO (continued)

CENTRAL RHPO

OSHAWA 3967 Deg Day

	SEMI DETACHED			ROW		
	427 CHRIS	554 NOR	560 NOR	448 MAL	432 MAL	440 MAL
JUN	90.63	325.69	135.94	235.06	178.42	135.94
JUL	79.30	82.13	127.44	84.96	101.95	178.42
AUG	209.57	184.08	124.61	107.62	152.93	73.63
SEP	76.47	76.47	118.95	82.13	99.12	172.76
OCT	365.34	300.20	337.02	67.97	252.05	87.79
NOV	263.38	659.87	294.53	209.57	243.56	325.69
DEC	688.19	492.78	308.69	124.61	733.50	235.06
JAN	438.97	546.59	458.79	376.66	430.47	532.43
FEB	1016.71	886.43	484.28	365.34	991.22	577.74
MAR	410.65	512.60	436.14	387.99	441.80	532.43
APR	410.65	538.09	331.35	203.91	1059.19	487.11
MAY	127.44	141.60	201.08	246.39	286.04	376.66
ENERGY SOURCE	NG & E	NG & E	NG & E	NG & E	NG & E	NG & E
TOT CONSUMP (m^3)	4177.29	4746.53	3358.82	2492.21	4970.26	3715.66
TOT CONSUMP (ekWh)	38826.43	44117.35	31219.08	23164.24	46196.87	34535.78
DHW GAS (ekWh)	13585.25	12742.75	13795.87	10215.26	13164.00	14427.74
ELECT (kWh)	5986.00	9858.65	10008.30	9599.50	6537.15	4361.75
HOUSE AREA ft^2	1473.00	1473.00	1473.00	1413.00	1413.00	1413.00
TOTAL ENERGY kWh/ft^2	30.42	36.64	27.99	23.19	37.32	27.53
SPACE HEATING kWh/DD/ft^2	0.00432	0.00537	0.00298	0.00231	0.00589	0.00359
ac/h at 50 PA						
ELA - SQ IN						

LEGEND - NG & E monthly values = m^3 gas, E monthly values = kWh
TOT CONSUMP = equivalent kiloWatt hours for NG & E energy source
ELA = equivalent leakage area, in^2
ac/h = air changes per hour
no. of degree days = average of 30 years

TABLE 1 - CENTRAL RHPO (continued)

CENTRAL RHPO SUMMARY

	DETACHED AVERAGE	S-DETACHED AVERAGE	ROW AVERAGE
TOT CONSUMP (m^3)	3949.70	4094.21	3726.05
TOT CONSUMP (ekWh)	36711.04	38054.28	34632.29
DHW GAS (ekWh)	9312.31	13374.62	12602.34
ELECT (kWh)	7923.42	8617.65	6832.80
HOUSE AREA ft^2	1400.00	1473.00	8245.80
TOTAL ENERGY kWh/ft^2	31.88	31.68	29.35
SPACE HEATING kWh/DD/ft^2	0.00434	0.00422	0.00393
ac/h at 50 PA	4.65		
ELA - SQ IN	117.37		

LEGEND - NG & E monthly values = m^3 gas, E monthly values = kWh
TOT CONSUMP = equivalent kiloWatt hours for NG & E energy source
ELA = equivalent leakage area, in^2
ac/h = air changes per hour
no. of degree days = average of 30 years

TABLE 2 - EASTERN RHPO

EASTERN RHPO

	TRENTON	4101 Deg Day	
	DETACHED		
	14 GRAH	27 GRAH	17 COREY
JUN	181.25	133.11	184.08
JUL	96.29	124.61	127.44
AUG	62.31	31.15	82.13
SEP	87.79	101.95	116.11
OCT	124.61	124.61	175.59
NOV	291.70	337.02	362.50
DEC	314.36	413.48	475.79
JAN	549.42	640.05	685.36
FEB	532.43	713.68	790.14
MAR	606.06	708.01	778.82
APR	294.53	489.95	461.63
MAY	232.23	297.37	308.69
ENERGY SOURCE	NG & E	NG & E	NG & E
TOT CONSUMP (m^3)	3372.98	4114.98	4548.29
TOT CONSUMP (ekWh)	31350.69	38247.32	42274.74
DHW GAS (ekWh)	9162.14	9583.39	12110.88
ELECT (kWh)	4555.20	6278.00	7420.45
HOUSE AREA ft^2	1840.00	1948.00	1948.00
TOTAL ENERGY kWh/ft^2	19.51	22.86	25.51
SPACE HEATING kWh/DD/ft^2	0.00294	0.00359	0.00378
ac/h at 50 PA	6.02	7.65	6.68
ELA - SQ IN	173.66	194.15	188.73

LEGEND - NG & E monthly values = m^3 gas, E monthly values = kWh
TOT CONSUMP = equivalent kiloWatt hours for NG & E energy source
ELA = equivalent leakage area, in^2
ac/h = air changes per hour
no. of degree days = average of 30 years

TABLE 2 - EASTERN RHPO (continued)

EASTERN RHPO

CARLETON PLACE 4596 Deg Day

	SEMI DETACHED					ROW		
	404 PAT	406 PAT	165 EDW	189 EDW	334 JOE	144 CALD	148 CALD	152 CALD
JUN	259.00	152.00	960.00	720.00	940.00	83.00	91.00	87.00
JUL	75.00	75.00	790.00	720.00	860.00	131.00	102.00	78.00
AUG	135.00	69.00	1230.00	740.00	1660.00	66.00	69.00	73.00
SEP	118.00	117.00	1260.00	850.00	2320.00	59.00	77.00	82.00
OCT	373.00	230.00	2000.00	1130.00	3350.00	107.00	119.00	109.00
NOV	410.00	394.00	2210.00	1780.00	3250.00	282.00	242.00	109.00
DEC	683.00	498.00	3250.00	2580.00	4710.00	339.00	408.00	317.00
JAN	499.00	478.00	3070.00	2590.00	4330.00	586.00	416.00	263.00
FEB	584.00	511.00	2490.00	1840.00	3650.00	429.00	521.00	397.00
MAR	433.00	415.00	2250.00	1410.00	3480.00	597.00	367.00	337.00
APR	348.00	290.00	1400.00	920.00	2230.00	369.00	445.00	345.00
MAY	73.00	73.00	1080.00	810.00	1660.00	290.00	101.00	68.00
ENERGY SOURCE	NG & E	NG & E	E	E	E	NG & E	NG & E	NG & E
TOT CONSUMP (m^3)	3990.00	3302.00				3338.00	2958.00	2265.00
TOT CONSUMP (ekWh)	37085.66	30690.94	21990.00	16090.00	32440.00	31025.55	27493.58	21052.39
DHW GAS (ekWh)	12196.90	9705.46	13120.00	9240.00	13840.00	9519.53	9222.05	8664.26
ELECT (kWh)	6570.00	6570.00				4606.30	8322.00	5621.00
HOUSE AREA ft^2	1615.00	1615.00	925.00	925.00	980.00	1073.00	1305.00	1073.00
TOTAL ENERGY kWh/ft^2	27.03	23.07	23.77	17.39	33.10	33.21	27.44	24.86
SPACE HEATING kWh/DD/ft^2	0.00335	0.00283	0.00209	0.00161	0.00413	0.00436	0.00305	0.00251
ac/h at 50 PA	8.50	8.85	5.14	4.38	7.26			
ELA - SQ IN	152.72	148.26	53.63	58.03	104.17			

LEGEND - NG & E monthly values = m^3 gas, E monthly values = kWh
TOT CONSUMP = equivalent kiloWatt hours for NG & E energy source
ELA = equivalent leakage area, in^2
ac/h = air changes per hour
no. of degree days = average of 30 years

TABLE 2 - EASTERN RHPO (continued)

EASTERN RHPO SUMMARY

	DETACHED AVERAGE	S-DETACHED AVERAGE	ROW AVERAGE
TOT CONSUMP (m^3)	4012.08	N/A	2853.67
TOT CONSUMP (ekWh)	37290.92	27659.32	26523.84
DHW GAS (ekWh)	10285.47	11620.47	9135.28
ELECT (kWh)	6084.55	N/A	6183.10
HOUSE AREA ft^2	1912.00	1212.00	1150.33
TOTAL ENERGY kWh/ft^2	22.63	24.87	28.50
SPACE HEATING kWh/DD/ft^2	0.00343	0.00280	0.00331
ac/h at 50 PA	6.78	6.83	
ELA - SQ IN	185.51	103.36	

LEGEND - NG & E monthly values = m^3 gas, E monthly values = kWh
TOT CONSUMP = equivalent kiloWatt hours for NG & E energy source
ELA = equivalent leakage area, in^2
ac/h = air changes per hour
no. of degree days = average of 30 years

TABLE 3 - SOUTHERN RHPO

SOUTHERN RHPO

HAMILTON 3592 Deg Day

DETACHED

	25 EATON	76 ARMS	80 ARMS	690 BRIT	740 BRIT
JUN	76.00	101.00	48.00	127.00	84.00
JUL	66.00	62.00	45.00	118.00	67.00
AUG	66.00	76.00	65.00	125.40	115.00
SEP	79.00	91.00	78.00	162.00	163.00
OCT	291.00	348.00	445.00	326.00	289.00
NOV	446.00	389.00	399.00	388.00	430.00
DEC	655.00	617.00	619.00	542.00	573.00
JAN	573.00	616.00	591.00	582.00	605.00
FEB	541.00	680.00	580.00	519.00	553.00
MAR	410.00	554.00	474.00	439.00	452.00
APR	256.00	352.00	275.00	274.00	249.00
MAY	130.00	147.00	109.00	173.00	144.00
ENERGY SOURCE	NG & E	NG & E	NG & E	NG & E	NG & E
TOT CONSUMP (m^3)	3589.00	4033.00	3728.00	3775.40	3724.00
TOT CONSUMP (ekWh)	33358.50	37485.33	34650.46	35091.03	34613.28
DHW GAS (ekWh)	7734.62	8887.37	5875.34	13773.57	9891.39
ELECT (kWh)	N/A	N/A	N/A	N/A	N/A
HOUSE AREA ft^2	1674.00	1680.00	1680.00	1660.00	1670.00
TOTAL ENERGY kWh/ft^2	19.93	22.31	20.63	21.14	20.73
SPACE HEATING kWh/DD/ft^2	0.00426	0.00474	0.00477	0.00358	0.00412
ac/h at 50 PA	9.63	16.81	11.48	14.40	22.40
ELA - SQ IN	149.20	381.67	238.93	297.04	314.88

LEGEND - NG & E monthly values = m^3 gas, E monthly values = kWh
TOT CONSUMP = equivalent kiloWatt hours for NG & E energy source
ELA = equivalent leakage area, in^2
ac/h = air changes per hour
no. of degree days = average of 30 years
N/A = unable to get Hydro bills

TABLE 3 - SOUTHERN RHPO (continued)

SOUTHERN RHPO

HAMILTON 3592 Deg Day

	SEMI DETACHED				ROW		
	14 ARBU	10 JUTL	8 CLEVE	20 EATON	22 PURN	32 PURN	44 PURN
JUN	132.40	95.80	104.20	166.00	73.30	749.40	152.10
JUL	138.10	81.70	81.70	75.00	50.70	140.90	138.10
AUG	124.00	87.30	101.40	75.00	62.00	262.00	157.80
SEP	242.30	107.10	293.00	125.00	200.00	642.00	281.70
OCT	369.10	270.50	169.00	250.00	236.50	653.60	366.30
NOV	433.90	211.30	484.60	347.00	315.50	659.30	633.90
DEC	555.00	307.10	611.40	497.00	498.70	780.40	611.40
JAN	755.10	532.50	309.90	485.00	400.10	1104.60	549.40
FEB	679.00	501.50	276.10	483.00	366.30	1236.80	414.20
MAR	557.80	343.70	121.10	401.00	233.80	1174.90	222.60
APR	366.30	216.90	118.30	263.00	140.90	822.70	169.00
MAY	160.60	90.20	93.00	156.00	95.80	693.10	171.90
ENERGY SOURCE	NG & E	NG & E	NG & E	NG & E	NG & E	NG & E	NG & E
TOT CONSUMP (m^3)	4513.60	2845.60	2763.70	3323.00	2673.60	8919.70	3868.40
TOT CONSUMP (ekWh)	41952.34	26448.86	25687.63	30886.13	24850.18	82905.50	35955.43
DHW GAS (ekWh)	14669.75	9846.76	10683.44	11750.67	6916.53	42849.04	16659.18
ELECT (kWh)	N/A	N/A	N/A	N/A	N/A	N/A	N/A
HOUSE AREA ft^2	1731.00	1872.00	1593.00	1273.00	1470.00	1470.00	1470.00
TOTAL ENERGY kWh/ft^2	24.24	14.13	16.13	24.26	16.90	56.40	24.46
SPACE HEATING kWh/DD/ft^2	0.00439	0.00247	0.00262	0.00418	0.00340	0.00759	0.00365
ac/h at 50 PA	4.80	6.24	5.19				
ELA - SQ IN	124.66	130.06	123.48				

LEGEND - NG & E monthly values = m^3 gas, E monthly values = kWh
TOT CONSUMP = equivalent kiloWatt hours for NG & E energy source
ELA = equivalent leakage area, in^2
ac/h = air changes per hour
no. of degree days = average of 30 years
N/A = unable to get Hydro bills

TABLE 3 - SOUTHERN RHPO (continued) SOUTHERN RHPO

3914 Deg Day

OAKVILLE	ROW MARG AVE **
JUN	6320.00
JUL	4880.00
AUG	5840.00
SEP	5680.00
OCT	14360.00
NOV	9440.00
DEC	18720.00
JAN	21080.00
FEB	21520.00
MAR	18360.00
APR	15440.00
MAY	8880.00
ENERGY SOURCE	E
TOT CONSUMP (m^3)	
TOT CONSUMP (ekWh)	30104.00
DHW GAS (ekWh)	13632.00
ELECT (kWh)	N/A
HOUSE AREA ft^2	1441.00
TOTAL ENERGY kWh/ft^2	21.14
SPACE HEATING kWh/DD/ft^2	0.00292
ac/h at 50 PA	2.86
ELA - SQ IN	56.72

** Includes 5 units

LEGEND - NG & E monthly values = m^3 gas, E monthly values = kWh
TOT CONSUMP = equivalent kiloWatt hours for NG & E energy source
ELA = equivalent leakage area, in^2
ac/h = air changes per hour
no. of degree days = average of 30 years

TABLE 3 - SOUTHERN RHPO (continued)

SOUTHERN RHPO SUMMARY

	DETACHED AVERAGE	S-DETACHED AVERAGE	ROW AVERAGE
TOT CONSUMP (m^3)	3769.88	3361.48	3865.43
TOT CONSUMP (ekWh)	35039.72	31243.74	43453.78
DHW GAS (ekWh)	9232.46	11737.66	20014.19
ELECT (kWh)	N/A	N/A	N/A
HOUSE AREA ft^2	1672.80	1617.25	1462.75
TOTAL ENERGY kWh/ft^2	20.95	19.69	29.73
SPACE HEATING kWh/DD/ft^2	0.00429	0.00342	0.00439
ac/h at 50 PA	14.94	5.41	2.86
ELA - SQ IN	276.34	126.07	56.72

LEGEND - NG & E monthly values = m^3 gas, E monthly values = kWh
TOT CONSUMP = equivalent kiloWatt hours for NG & E energy source
ELA = equivalent leakage area, in^2
ac/h = air changes per hour
no. of degree days = average of 30 years
N/A = unable to get Hydro bills

TABLE 4 - SOUTHWESTERN RHPO

SOUTHWESTERN RHPO

	PORT ELGIN		4235 Deg Day	LISTOWEL		4810 Deg Day
	DETACHED			SEMI DETACHED		
	372 PRO KWH	446 CATH KWH	467 BRU KWH	907 DAV	911 DAV	933 DAV
JUN	0.00	0.00	0.00	50.70	50.70	53.50
JUL	3000.00	1500.00	2580.00	31.00	31.00	42.30
AUG	0.00	0.00	0.00	45.10	36.60	47.90
SEP	2240.00	1550.00	2240.00	62.00	36.60	56.30
OCT	0.00	0.00	0.00	225.40	152.10	160.60
NOV	3510.00	3520.00	5150.00	329.60	255.40	226.20
DEC	0.00	0.00	0.00	535.30	419.80	355.00
JAN	6920.00	7670.00	6440.00	540.90	417.00	394.40
FEB	0.00	0.00	0.00	487.40	309.90	293.00
MAR	8770.00	8190.00	8770.00	462.10	225.40	202.90
APR	0.00	0.00	0.00	253.60	73.30	73.30
MAY	3470.00	5390.00	4560.00	157.80	87.30	140.90
ENERGY SOURCE	E	E	E	NG & E	NG & E	NG & E
TOT CONSUMP (m^3)	N/A	N/A	N/A	3180.90	2095.10	2048.30
TOT CONSUMP (ekWh)	27910.00	27820.00	29740.00	29565.36	19473.22	19038.23
DHW GAS (ekWh)	15720.00	9150.00	14460.00	5135.34	3874.75	5447.70
ELECT (kWh)	N/A	N/A	N/A	5391.05	6088.20	5708.60
HOUSE AREA ft^2	1600.00	1735.00	1735.00	1350.00	1350.00	1350.00
TOTAL ENERGY kWh/ft^2	17.44	16.03	17.14	25.89	18.93	18.33
SPACE HEATING kWh/DD/ft^2	0.00180	0.00254	0.00208	0.00376	0.00240	0.00209
ac/h at 50 PA	5.46	5.08	4.94	6.16	4.80	7.39
ELA - SQ IN	108.94	110.88	112.02	107.07	84.16	160.15

LEGEND - NG & E monthly values = m^3 gas, E monthly values = kWh
TOT CONSUMP = equivalent kiloWatt hours for NG & E energy source
ELA = equivalent leakage area, in^2
ac/h = air changes per hour
no. of degree days = average of 30 years

TABLE 4 - SOUTHWESTERN RHPO (continued)

SOUTHWESTERN RHPO

	LONDON	4132 Deg Day		
		DETACHED		ROW
	201 FAIR	240 ATKI	193 BUR	424 BOUL ***
JUN	56.30	112.70	76.10	200.00
JUL	62.00	104.20	78.90	191.60
AUG	163.40	118.30	129.60	315.50
SEP	366.30	295.80	185.90	912.80
OCT	484.60	380.30	290.20	1065.00
NOV	473.30	515.60	611.40	1222.80
DEC	431.10	571.90	738.20	1927.10
JAN	422.60	540.90	656.50	1634.10
FEB	312.70	397.30	459.20	1132.60
MAR	146.50	281.70	346.50	1017.10
APR	78.90	140.90	146.50	481.80
MAY	78.90	126.80	84.50	295.80
ENERGY SOURCE	NG & E	NG & E	NG & E	NG & E
TOT CONSUMP (m^3)	3076.60	3586.40	3803.50	10396.20
TOT CONSUMP (ekWh)	28595.92	33334.34	35352.21	24157.26
DHW GAS (ekWh)	7333.01	12464.64	10583.04	6573.50
ELECT (kWh)	15786.25	3748.55	6778.05	6894.85
HOUSE AREA ft^2	1620.00	1112.00	1826.00	1386.00
TOTAL ENERGY kWh/ft^2	27.40	33.35	23.06	22.40
SPACE HEATING kWh/DD/ft^2	0.00318	0.00454	0.00330	0.00307
ac/h at 50 PA	7.30	7.67	10.04	
ELA - SQ IN	155.94	163.97	260.64	

*** Includes 4 Units

LEGEND - NG & E monthly values = m^3 gas, E monthly values = kWh
TOT CONSUMP = equivalent kiloWatt hours for NG & E energy source
ELA = equivalent leakage area, in^2
ac/h = air changes per hour
no. of degree days = average of 30 years

TABLE 4 - SOUTHWESTERN RHPO (continued)

SOUTHWESTERN RHPO SUMMARY

	DETACHED AVERAGE	S-DETACHED AVERAGE	ROW AVERAGE
TOT CONSUMP (m^3)	15989.42	2441.43	10396.20
TOT CONSUMP (ekWh)	30458.74	22692.27	24157.26
DHW GAS (ekWh)	11618.45	4819.26	6573.50
ELECT (kWh)	N/A	5729.28	6894.85
HOUSE AREA ft^2	1419.33	1350.00	1386.00
TOTAL ENERGY kWh/ft^2	21.68	21.05	22.40
SPACE HEATING kWh/DD/ft^2	0.00291	0.00275	0.00307
ac/h at 50 PA	6.75	6.12	
ELA - SQ IN	152.07	117.13	

LEGEND - NG & E monthly values = m^3 gas, E monthly values = kWh
TOT CONSUMP = equivalent kiloWatt hours for NG & E energy source
ELA = equivalent leakage area, in^2
ac/h = air changes per hour
no. of degree days = average of 30 years

TABLE 5 - NORTHERN RHPO

NORTHERN RHPO

NORTH BAY 4990 Deg Day

	DETACHED			SEMI DETACHED		
	952 BUR	976 REY	885 BUR	1745 DIE	1741 LAU	1736 JA
JUN	119.00	46.00	24.00	36.00	47.00	26.00
JUL	53.00	36.00	22.00	35.00	55.00	34.00
AUG	79.00	36.00	13.00	30.00	50.00	23.00
SEP	107.00	74.00	53.00	59.00	50.00	31.00
OCT	136.00	105.00	80.00	86.00	78.00	63.00
NOV	236.00	189.00	159.00	167.00	172.00	101.00
DEC	343.00	168.00	166.00	167.00	130.00	121.00
JAN	293.00	308.00	275.00	238.00	140.00	182.00
FEB	315.00	197.00	163.00	220.00	166.00	151.00
MAR	233.00	217.00	188.00	174.00	133.00	142.00
APR	270.00	94.00	68.00	115.00	104.00	82.00
MAY	80.00	69.00	54.00	49.00	63.00	55.00
ENERGY SOURCE	NG & E	NG & E	NG & E	NG & E	NG & E	NG & E
TOT CONSUMP (CCF)	2264.00	1539.00	1265.00	1376.00	1188.00	1011.00
TOT CONSUMP (ekWh)	59595.27	40511.10	33298.60	36220.45	31271.72	26612.55
DHW GAS (ekWh)	26433.31	12426.82	6213.41	10636.51	16007.42	8740.90
ELECT (kWh)	5383.75	3642.70	2394.40	5982.35	11935.50	6580.95
HOUSE AREA ft^2	1600.00	1700.00	1288.00	1440.00	1440.00	1440.00
TOTAL ENERGY kWh/ft^2	40.61	25.97	27.71	30.14	30.86	23.71
SPACE HEATING kWh/DD/ft^2	0.00406	0.00331	0.00421	0.00356	0.00212	0.00249
ac/h at 50 PA	8.31	7.92	6.15	4.67	4.20	4.16
ELA - SQ IN	182.24	144.52	109.09	74.48	75.64	74.30

LEGEND - NG & E monthly values = ft^3 gas, E monthly values = kWh
TOT CONSUMP = equivalent kiloWatt hours for NG & E energy source
ELA = equivalent leakage area, in^2
ac/h = air changes per hour
no. of degree days = average of 30 years

TABLE 5 - NORTHERN RHPO (continued)

NORTHERN RHPO

NORTH BAY 4990 Deg Day

	ROW		
	25 MAN	55 MAN	51 MAN
JUN	126.00	94.00	54.00
JUL	83.00	61.00	14.00
AUG	68.00	52.00	17.00
SEP	44.00	31.00	16.00
OCT	48.00	33.00	4.00
NOV	31.00	29.00	22.00
DEC	72.00	53.00	23.00
JAN	234.00	161.00	62.00
FEB	172.00	131.00	92.00
MAR	182.00	142.00	96.00
APR	126.00	94.00	54.00
MAY	83.00	61.00	14.00
ENERGY SOURCE	NG & E	NG & E	NG & E
TOT CONSUMP (CCF)	1269.00	942.00	468.00
TOT CONSUMP (ekWh)	33403.89	24796.27	12319.16
DHW GAS (ekWh)	12953.38	9794.02	8951.52
ELECT (kWh)	4785.15	4606.30	5683.05
HOUSE AREA ft^2	1120.00	1120.00	1254.00
TOTAL ENERGY kWh/ft^2	34.10	26.25	14.36
SPACE HEATING kWh/DD/ft^2	0.00366	0.00268	0.00054
ac/h at 50 PA			
ELA - SQ IN			

LEGEND - NG & E monthly values = ft^3 gas, E monthly values = kWh
TOT CONSUMP = equivalent kiloWatt hours for NG & E energy source
ELA = equivalent leakage area, in^2
ac/h = air changes per hour
no. of degree days = average of 30 years

TABLE 5 - NORTHERN RHPO (continued)

NORTHERN RHPO SUMMARY

	DETACHED AVERAGE	S-DETACHED AVERAGE	ROW AVERAGE
TOT CONSUMP (CCF)	1689.33	1191.67	893.00
TOT CONSUMP (ekWh)	44468.32	31368.24	23506.44
DHW GAS (ekWh)	15024.51	11794.94	10566.30
ELECT (kWh)	3806.95	8166.27	5024.83
HOUSE AREA ft^2	1529.33	1440.00	1164.67
TOTAL ENERGY kWh/ft^2	31.43	28.24	24.90
SPACE HEATING kWh/DD/ft^2	0.00386	0.00272	0.00229
ac/h at 50 PA	7.46	4.34	
ELA - SQ IN	145.28	74.81	

LEGEND - NG & E monthly values = ft^3 gas, E monthly values = kWh
TOT CONSUMP = equivalent kiloWatt hours for NG & E energy source
ELA = equivalent leakage area, in^2
ac/h = air changes per hour
no. of degree days = average of 30 years

TABLE 6 - NORTHWESTERN RHPO

NORTHWESTERN RHPO

THUNDER BAY 5673 Deg Day

	DETACHED			SEMI DETACHED		
	575 MGIL	517 SIM	528 SIM	2808 DON	207 GREY	205 GREY
JUN	85.00	176.00	65.00	93.00	82.00	68.00
JUL	110.00	150.00	65.00	54.00	57.00	40.00
AUG	102.00	74.00	88.00	102.00	76.00	42.00
SEP	144.00	167.00	88.00	71.00	71.00	51.00
OCT	295.00	331.00	187.00	93.00	79.00	71.00
NOV	397.00	436.00	289.00	116.00	142.00	110.00
DEC	317.00	428.00	340.00	195.00	215.00	178.00
JAN	759.00	833.00	581.00	181.00	249.00	198.00
FEB	507.00	558.00	518.00	272.00	306.00	229.00
MAR	425.00	487.00	351.00	187.00	246.00	193.00
APR	365.00	459.00	346.00	161.00	164.00	113.00
MAY	221.00	261.00	167.00	116.00	127.00	96.00
ENERGY SOURCE	NG & E	NG & E	NG & E	NG & E	NG & E	NG & E
TOT CONSUMP (m^3)	3727.00	4360.00	3085.00	1641.00	1814.00	1389.00
TOT CONSUMP (ekWh)	34641.17	40524.68	28674.00	15252.52	16860.50	12910.27
DHW GAS (ekWh)	11044.14	14874.27	8106.48	9259.23	7994.92	***
ELECT (kWh)	7365.70	6285.30	13150.95	5898.40	2416.30	6646.65
HOUSE AREA ft^2	1677.00	1677.00	1677.00	472.00	472.00	472.00
TOTAL ENERGY kWh/ft^2	25.05	27.91	24.94	44.81	40.84	41.43
SPACE HEATING kWh/DD/ft^2	0.00248	0.00270	0.00216	0.00224	0.00331	0.00482
ac/h at 50 PA	3.47	3.68	2.92	8.03	11.71	12.20
ELA - SQ IN	77.30	85.17	63.60	52.24	79.24	89.81

LEGEND - NG & E monthly values = m^3 gas, E monthly values = kWh
TOT CONSUMP = equivalent kiloWatt hours for NG & E energy source
ELA = equivalent leakage area, in^2
ac/h = air changes per hour
no. of degree days = average of 30 years

** electrically heated

TABLE 6 - NORTHWESTERN RHPO (continued)

NORTHWESTERN RHPO

	THUNDER BAY	5673 Deg Day		NIPIGON	5673 Deg Day	
		ROW			DETACHED	
	46 JOH	43 JOH	40 JOH	165 GRE KWH	166 GRE KWH	167 GRE KWH
JUN	108.00	68.00	76.00	850.00	900.00	1300.00
JUL	147.00	73.00	78.00	850.00	850.00	1100.00
AUG	130.00	68.00	82.00	1000.00	1000.00	1700.00
SEP	133.00	82.00	122.00	1350.00	1450.00	2000.00
OCT	175.00	150.00	165.00	3100.00	2400.00	4700.00
NOV	385.00	178.00	235.00	4350.00	3350.00	4700.00
DEC	399.00	252.00	283.00	5900.00	4400.00	5950.00
JAN	609.00	465.00	473.00	6900.00	4950.00	7350.00
FEB	671.00	456.00	499.00	4850.00	3350.00	5350.00
MAR	513.00	368.00	363.00	3000.00	2950.00	5950.00
APR	374.00	280.00	265.00	2150.00	2200.00	4400.00
MAY	493.00	145.00	130.00	1750.00	1400.00	2450.00
ENERGY SOURCE	NG & E	NG & E	NG & E	E	E	E
TOT CONSUMP (m^3)	4137.00	2585.00	2771.00			
TOT CONSUMP (ekWh)	38451.97	24026.67	25755.48	36050.00	29200.00	46950.00
DHW GAS (ekWh)	14316.48	7771.80	8775.82	10800.00	11000.00	16400.00
ELECT (kWh)	3938.35	2792.25	3215.65	N/A	N/A	N/A
HOUSE AREA ft^2	1381.00	1381.00	1381.00	1440.00	1440.00	1802.00
TOTAL ENERGY kWh/ft^2	30.70	19.42	20.98	25.03	20.28	26.05
SPACE HEATING kWh/DD/ft^2	0.00308	0.00207	0.00217	0.00309	0.00225	0.00299
ac/h at 50 PA				3.22	4.31	6.34
ELA - SQ IN				79.16	79.75	188.76

LEGEND - NG & E monthly values = m^3 gas, E monthly values = kWh
TOT CONSUMP = equivalent kiloWatt hours for NG & E energy source
ELA = equivalent leakage area, in^2
ac/h = air changes per hour
no. of degree days = average of 30 years

TABLE 6 - NORTHWESTERN RHPO (continued)

	DETACHED AVERAGE	S-DETACHED AVERAGE	ROW AVERAGE
TOT CONSUMP (m^3)	N/A	1614.67	1785.33
TOT CONSUMP (ekWh)	36006.64	15007.76	28610.72
DHW GAS (ekWh)	12037.46	5751.38	9115.87
ELECT (kWh)	N/A	4987.12	2002.63
HOUSE AREA ft^2	1618.83	472.00	1381.00
TOTAL ENERGY kWh/ft^2	24.88	42.36	21.81
SPACE HEATING kWh/DD/ft^2	0.00261	0.00346	0.00244
ac/h at 50 PA	3.99	10.65	
ELA - SQ IN	95.62	73.76	

LEGEND - NG & E monthly values = m^3 gas, E monthly values = kWh
TOT CONSUMP = equivalent kiloWatt hours for NG & E energy source
ELA = equivalent leakage area, in^2
ac/h = air changes per hour
no. of degree days = average of 30 years

TABLE 7 - Six Worst Energy Users - Comparison of Actual Energy Usage to Optimum Energy Usage

House Address	House Type	Energy Source	Total Actual Energy Consumption (KWHS)	DHW ** (KWHS)	% of Tot Act Consump	Net Actual Consumptio (KWHS)	% of Tot Act Consump	Calculated Consumption (OEU) (KWHS)	Net Actual Consump divided by OEU x 100
517 Simon Fraser	D	NG & E	40524.68	14874.27	36.70	25650.41	63.30	26129.94	98.16
165 Greenmantle	D	E	36050.00	10800.00	29.96	25250.00	70.04	27260.91	92.62
907 Davidson	SD	NG & E	29565.36	5135.34	17.37	24430.02	82.63	15037.40	162.46
334 Joseph	SD	E	32440.00	13840.00	42.66	18600.00	57.34	7897.03	235.53
144 Caldwell	R	NG & E	31025.55	9519.53	30.68	21506.02	69.32	16446.87	130.76
32 Purnell	R	NG & E	82905.50	42849.04	51.68	40056.46	48.32	14560.80	275.10
Averages			42085.18	16169.70	34.84	25915.49	65.16	17888.83	144.87

LEGEND

Total Actual Energy Consump = Space Heating + DHW heating

Net Actual Consumption = Space Heating - DHW heating

Calculated Consumption = Optimum Energy Usage (HOT-2000 Calculated)
(Total Losses - Solar Gains - Internal Gains) / Seasonal Efficiency

** = DHW heater values for electrically heated houses include electricity used for lighting etc.

D = Detached
SD = Semi-Detached
R = Row House
NG & E = Natural Gas and Electricity
E = Electricity

TABLE 8 - Six Worst Energy Users - Heat Losses, Heat Gains and Seasonal Furnace Efficiencies

House Address	House Type	Energy Source	Envelope Losses (KWHS)	ASHRAE Minimum Ventilation (KWHS)	ac/h	Total Losses (KWHS)	Solar Gain (KWHS)	Internal Gains (KWHS)	Seasonal Efficiency (%)
517 Simon Fraser	D	NG & E	20841.28	5348.28	0.26	26189.56	4550.61	6222.28	59.00
165 Greenmantle	D	E	28681.53	8977.44	0.35	37658.97	4828.60	5569.46	100.00
907 Davidson	SD	NG & E	14433.05	5725.17	0.46	20158.22	3237.62	4289.18	84.00
334 Joseph	SD	E	9610.31	6182.24	0.60	15792.55	2341.05	5554.47	100.00
144 Caldwell	R	NG & E	10345.75	6038.68	0.45	16384.43	2578.38	3773.46	60.60
32 Purnell	R	NG & E	10917.08	5520.07	0.40	16437.15	2973.92	4581.14	52.00
Averages			15804.83	6298.65	0.42	22103.48	3418.36	4998.33	

LEGEND

Total losses = envelope losses + ventilation

D = Detached
SD = Semi-Detached
R = Row House
NG & E = Natural Gas and Electricity
E = Electricity

TABLE 9 - Six Worst Energy Users - Breakdown of Energy Losses Through Envelope (above grade components)

House Address	House Type	Energy Source	Envelope Losses							
			Ceiling (KWHS)	% of Tot Losses	Walls (KWHS)	% of Tot Losses	Doors (KWHS)	% of Tot Losses	Windows (KWHS)	% of Tot Losses
517 Simon Fraser	D	NG & E	3263.89	12.46	5131.21	19.59	285.07	1.09	4234.16	16.17
165 Greenmantle	D	E	1544.10	4.10	6404.92	17.01	544.98	1.45	4594.20	12.20
907 Davidson	SD	NG & E	899.50	4.46	4567.83	22.66	404.34	2.01	2865.51	14.22
334 Joseph	SD	E	1092.88	6.92	3299.15	20.89	451.21	2.86	3205.39	20.30
144 Caldwell	R	NG & E	2127.16	12.98	1655.44	10.10	451.22	2.75	2710.23	16.54
32 Purnell	R	NG & E	1432.76	8.72	2385.00	14.51	407.27	2.48	3346.03	20.36
Averages			1726.71	8.27	3907.26	17.46	424.01	2.11	3492.59	16.63

LEGEND

D	=	Detached
SD	=	Semi-Detached
R	=	Row House
NG & E	=	Natural Gas and Electricity
E	=	Electricity

TABLE 10 - Six Worst Energy Users - Breakdown of Energy Losses Through Envelope
(below grade components)

House Address	House Type	Energy Source	Envelope Losses					
			Basement abv gr (KWHS)	% of Tot Losses	Basement walls (KWHS)	% of Tot Losses	Basement floor (KWHS)	% of Tot Losses
517 Simon Fraser	D	NG & E	1896.09	7.24	3331.89	12.72	2698.98	10.31
167 Greenmantle	D	E	5895.11	15.65	6103.14	16.21	3595.08	9.55
907 Davidson	SD	NG & E	1236.45	6.13	3305.01	16.40	1154.41	5.73
334 Joseph	SD	E	0.00	0.00	0.00	0.00	1561.68	9.89
144 Caldwell	R	NG & E	1555.82	9.50	911.22	5.56	934.66	5.70
32 Purnell	R	NG & E	474.65	2.89	1684.73	10.25	1186.64	7.22
Averages			2211.62	8.28	3067.20	12.23	2226.29	9.68

LEGEND

D	=	Detached
SD	=	Semi-Detached
R	=	Row House
NG & E	=	Natural Gas and Electricity
E	=	Electricity

TABLE 11 - SUMMARY OF FURNACE, DHW AND BLOWER DOOR TESTS

Housing Authority	House Address	House Type	Steady State Furnace Efficiency %	Steady State DHW Heater Efficiency %	Blower Door Test *	Furnace Model	DHW Model
	SOUTHERN RHPO						
Hamilton Wentworth	20 Eaton	SD	76.7	75.1		Olsen BDS 100E	RHEEM RG40 36M
	25 Eaton	D	76.6	74.2	9.63	Olsen BDS 100E	RHEEM RG40 36M
	76 Armstrong	D	76.1	74.6	16.81	Olsen BDS 100E	RHEEM RG40 36M
	80 Armstrong	D	76.4	75.6	11.48	Olsen BDS 100E	GSW 564ONA 04
	690 Britannia	D	**	74.8	14.40	Olsen HCS2 81AD	RHEEM RG40 36M
	740 Britannia	D	**	75.3	22.40	Olsen HCS2 81AD	RHEEM RG40 36M
	22 Purnell	D	65.7	75.5		Furnaceman FG 60	RHEEM RG40 36M
	32 Purnell	R	66.7	75.0		Furnaceman FG 60	RHEEM RG40 36M
	44 Purnell	R	68.5	74.9		Furnaceman FG 60	RHEEM RG40 36M
	14 Arbutus	SD	72.4	74.8	4.80	Clare Bro HBG 75M	RHEEM RG40 40S
	10 Jutland	SD	72.9	76.5	6.24	Inter City HGB 50	John Wood JW C 402 02
	8 Cleveland	SD	67.9	76.9	5.19	Clare Bro HBG 75M	RHEEM RG40 40S
Halton	351 Margaret	R		electrically	2.99		Knight AMD 40 18N
	353 Margaret	R		heated	2.88		Giant (No model No.)
	355 Margaret	R			2.99		RHEEM TE40
	357 Margaret	R			2.86		Knight AMD 40 18N
	359 Margaret	R			2.56		Knight AMD 40 18N
	CENTRAL RHPO						
Durham Regional	427 Christine	SD	72.8	75.6		Clawsey 50HRT	John Wood CG 302 NT
	554 Normandy	SD	74.3	75.4		Clawsey 50HRT	John Wood CG 302 02
	560 Normandy	SD	75.1	71.9		Clawsey 50HRT	RUUD EH40 313
	432 Malaga	R	76.0	71.6		Lennox G8 82T	GSW 5G40NA 08
	440 Malaga	R	77.5	75.7		Lennox G8 82T	RUUD RG40 36M
	448 Malaga	R	76.9	75.4		Lennox G8 82T	RUUD RG40 36M
Victoria Haliburton	124 King	D	75.6	76.1	4.67	Keeprite LGF 090 NS	GSW 5G40N
	146 King	D	75.7	74.9	4.60	Findlays 2L100 FC	Gullstream 5G40N 33M
	154 King	D	75.5	74.4	4.68	Findlays 2L100 FC	RUUD RG40 36M

LEGEND

* AC/H at 50 Pa
** High Efficiency Furnace
*** Mid Efficiency Furnace
D Detached
SD Semi-Detached
R Row house

TABLE 11 - SUMMARY OF FURNACE, DHW AND BLOWER DOOR TESTS (continued)

Housing Authority	House Address	House Type	Steady State Furnace Efficiency %	Steady State DHW Heater Efficiency %	Blower Door Test *	Furnace Model	DHW Model
	SOUTHWESTERN RHPO						
London and Middlesex	201 Fairway	D	74.1	74.5	7.30	Inter City LGD 125	John Wood JW 402 04
	240 Atkinson	D	75.4	75.9	7.67	Olsen HAS 105A	John Wood JWC 402 04
	193 Burnside	D	78.2	76.6	10.04	Olsen HAS 80A	RHEEM 36M
	424 Boulee	R	77.8	72.7		Clare HBG 50	GSW 5G40NA 04
	426 Boulee	R	78.8	74.2		Clare HBG 50	RHEEM 36M
	428 Boulee	R	79.0	74.9		Clare HBG 50	RHEEM 36M
	430 Boulee	R	78.8	75.7		Clare HBG 50	RHEEM 36M
Perth and Stratford	372 Provincial	D		electrically heated	5.46		
	446 Catherine	D			5.08		
	467 Bruce	D			4.94		
	907 Davidson	SD	***	70.5	6.16	Olsen HMS 105A	GSW 5G40NA 04
	911 Davidson	SD	***	70.6	4.80	Olsen HMS 105A	GSW 5G40NA 04
	933 Davidson	SD	***	73.6	7.39	Olsen HMS 105A	GSW 5G40NA 04
	EASTERN RHPO						
Lanark County	404 Pattie	SD	75.6	76.1	8.50	Olsen BDS 10P	RUUD RG40 36M
	406 Pattie	SD	75.3	73.4	8.85	Olsen BDS 10P	RUUD RG40 36M
	165 Edwards	SD		electrically heated	5.14		
	189 Edwards	SD			4.38		
	334 Joseph	SD			7.26		
	144 Caldwell	R	75.6	72.1			
	148 Caldwell	R	75.2	74.9		Beach SL 650	GSW 5G40 NS
	152 Caldwell	R	72.1	74.1		Beach SL 650	RUUD RG40 36M
Hastings and Prince Edward	14 Graham	D	77.5	72.0	6.02	Cdn Coleman TM 83	RHEEM RG40 36M
	27 Graham	D	77.8	72.1	7.65	Cdn Coleman TM 83	John Wood JW50 2NA 04
	17 Corey	D	76.4	71.5	6.68	Cdn Coleman TM 83	GSW 5G40A 04

LEGEND

* AC/H at 50 Pa
** High Efficiency Furnce
*** Mid Efficiency Furnce
D Detached
SD Semi-Detached
R Row house

TABLE 11 - SUMMARY OF FURNACE, DHW AND BLOWER DOOR TESTS (continued)

Housing Authority	House Address	House Type	Steady State Furnace Efficiency %	Steady State DHW Heater Efficiency %	Blower Door Test *	Furnace Model	DHW Model
	NORTHERN RHPO						
	952 Burns	D	71.9	70.9	8.31	Olsen BDS 130	RHEEM RG40 36M
Nipissing and	976 Reynolds	D	72.4	77.0	7.92	Olsen BDS 130	RHEEM RG40 33S
Parry Sound	865 Burns	D	75.3	72.2	6.15	Olsen BDS 130	RHEEM RG40 33M
	1751 Diefnbker	SD	76.5	77.9	4.67	Olsen HBS 2	RHEEM RG40 36M
	1741 St Laurnt	SD	75.6	71.9	4.20	Olsen HBS 2	RHEEM RG40 36M
	1736 Jane	SD	75.9	74.0	4.16	Olsen HBS 2	RHEEM RG40 36M
	25 Manitou	R	76.9	73.9		Anthes HGB 60	RHEEM RG40 36M
	51 Manitou	R	75.3	75.1		Anthes HGB 60	RHEEM RG40 36M
	55 Manitou	R	76.4	73.1		Anthes HGB 60	RHEEM RG40 36M
	NORTHWESTERN RHPO						
	575 McGill	D	73.8	76.0	3.47	Olsen WAS 80A	RHEEM RG40 36M
Thunder Bay	517 Simon Fr	D	73.6	73.2	3.68	Olsen WAS 80A	RHEEM RG40 36M
District	528 Simon Fr	D	75.7	74.5	2.92	Olsen WAS 80A	GSW
	2808 Donald	SD	77.7	73.9	8.03	Olsen WAS 80A	John Wood JWC 302 04
	205 Grey	SD	75.5	electric	11.71	Olsen WAS 80A	Vauhgan C40
	207 Grey	SD	75.2	75.4	12.20	Olsen WAS 80A	John Wood JM 302 NT
	40 John	R	71.6	75.8		Furnasman HG 90 26	John Wood JWC 402 04
	43 John	R	71.8	73.6		Furnasman HG 90 26	RHEEM RG40 33M
	46 John	R	70.6	72.1		Furnasman HG 90 26	RHEEM RG40 33M
	165 Greenmntle	D		electrically	3.22		GSW 5E175 778
	166 Greenmntle	D		heated	4.31		RUUD 7EE 40 D
	167 Greenmntle	D			6.34		
Averages			74.8	74.3	6.7		

LEGEND

* AC/H at 50 Pa
** High Efficiency Furnce
*** Mid Efficiency Furnce
D Detached
SD Semi-Detached
R Row house

TABLE 12 - Blower Door Tests vs Energy and House Type

Energy Sources	House Type	Houses Inspected	
		Average Blower Door Test *	Estimated Natural Air Change
Natural Gas and electrical	Detached	8.3	0.56
	Semi-Detached	6.9	0.46
	Row	**	**
Electrical	Detached	4.9	0.29
	Semi-Detcahed	5.6	0.42
	Row	2.9	0.20

* AC/H at 50 Pa
** no houses tested

TABLE 13 - Comparison of Blower Door Test and Natural Air Changes For Detached Houses

	Average Blower Door Test *	Estimated Natural Air Change **
Existing OHC	8.3	0.56
New Conven.	5.0	0.3 - 0.4
R - 2000	1.5	less than 0.1

* AC/H at 50 Pa
** AC/H

Volume

2

ENERGY MANAGEMENT PROGRAM FOR HOUSES

VOLUME 2

ENERGY MANAGEMENT MANUAL

Ministry
of
Housing

Ontario

TECHNICAL SUPPORT SERVICES BRANCH

Ontario Ministry of Housing

Technical Support Services Branch

ENERGY MANAGEMENT PROGRAM FOR HOUSES

VOLUME 2

ENERGY MANAGEMENT MANUAL

June 1989

For Use Within the Confines of the Government of Ontario
and its Agencies

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with

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2.0 PROCEDURE AT A TYPICAL HOUSING PROJECT

(1) Conducting the Energy Audit

Project Address: _____

Location: _____

House Type: _____

Submitted by: _____

Telephone: _____

Date: _____

ENERGY AUDIT

The Energy Audit allows housing personnel to calculate potential energy cost savings in their houses. It also indicates the building components most likely to provide those savings.

The audit is designed for detached, semi-detached and row houses.

The audit proceeds in logical stages:

* analysis of the past year's energy use.
* calculation of the Building Energy Performance Index (BEPI)
* measurement of building dimensions and areas.
* calculations of the Optimum Energy Usage (OEU) for space heating.
* calculation of the OEU for DHW heating.
* calculation for potential energy and cost savings.

You are advised to collect all building information necessary to complete the audit before beginning the calculations. That information is summarized as follows:

* 13 consecutive months of fuel (gas or oil) and electricity bills (see pages 3, 4 and 5).
* building blueprints or detailed on site measurements (see pages 6 and 7).
* house checklist (see pages 23 and 24).
* metering arrangements, i.e., bulk or independent metering for row houses

Be sure to read the notes for each section before beginning the calculations!

CURRENT ENERGY USE

1. Before you begin, you will need copies of 13 consecutive months of fuel (gas or oil) and electricity bills and the house floor area.

2. From the first bill, you take only the reading date. This determines when the period of current energy use begins. (line 1)

3. Now enter all the reading dates and energy use information called for from the other twelve bills for each utility.

4. Add up the energy consumption and cost columns. (line 2)

5. Work out the number of days in the energy use period for fuel and for electricity. This is the number of days from reading date 1 to reading date 13.

	no. of days in period	PERIOD FACTOR = 365/no.of days
Fuel		
Electricity		

Then divide that number of days into 365 to develop PERIOD FACTORS. These factors normalize actual energy use to one full year. Factors will normally be between 0.8 and 1.2.

6. Fuel factors are used to convert gas or oil units into energy units (equivalent kiloWatt-hours (ekWh)) so that electricity and fuel use can be directly compared and combined.

To choose the correct fuel units, you must know:
* Your type of fuel (Natural gas, No. 2 oil, etc.)
* The units your fuel is measured in (M^3, litres, etc.)

The factors are as follows:

NATURAL GAS			FUEL OIL	
			No.2	
CCF	MCF	M^3	Gallon	Litre
29.3	293.1	10.4	48.9	10.8

7. Calculate energy units per year for fuel and for electricity. (lines 3 and 4). The total energy use (fuel and electricity) should go to page 22 line 9.

8. Calculate the average cost per energy unit for fuel and for electricity. Divide the total cost of fuel for the year from the table by the total fuel energy units used (line 5). Then do the same for electricity (line 6). Remember that these average costs are out of date. Your utility companies can tell you the percentage increases since the period of your analysis, and you may thereby calculate current average costs. The average energy unit cost should go to page 22 line 13.

9. Calculate the total energy used (line 7) by adding line 3 and 4.

10. Calculate the Building Performance Index (BEPI) (line 8) by dividing line 7 by the house area.

11. If the calculated BEPI is greater than the target BEPI's in the table below, then proceed with the next calculation worksheets.

Type of House	Space & DHW Heating Energy Source	Target BEPI (Average For All of Ontario) ekWh/ft^2/yr
Detached, Semi-detached and Row houses	natural gas	25
	electricity	20

Current Energy Use Record

	FUEL (Oil or Gas) Type _____		Meter Reading Dates (Not billing or discount dates)			Electricity	
	Consump ( )	Cost $	Fuel		Elec.	Consump (kWh)	Cost $
1				1			
				2			
				3			
				4			
				5			
				6			
				7			
				8			
				9			
				10			
				11			
				12			
				13			
2			TOTALS				

3 Total Fuel [ ] x Period Factor Fuel [ ] (Note 5) x Fuel Factor [ ] (Note 6) = Energy Units/Year ekWh/yr [ ] (to Page 22, Line 9) FUEL

4 Total Electricity [ ] x Period Factor Elec [ ] (Note 5) x Fuel Factor [ ] = Energy Units/Year kWh/yr [ ] (to Page 22, Line 9) ELECTR

5 Total Fuel Cost $ [ ] (Line 2) x Period Factor Fuel [ ] (Note 5) ÷ Fuel Energy Units/Year [ ] (Line 3) = Average Cost $/Energy Unit [ ] (Note 8) FUEL

6 Total Electricity Cost $ [ ] (Line 2) x Period Factor Elec [ ] (Note 5) ÷ Electricity Energy Units/Year [ ] (Line 4) = Average Cost $/Energy Unit [ ] (Note 8) ELECTR

7 Fuel Energy ekWh/yr [ ] (Line 3) + Electricity Energy kWh/yr [ ] (Line 4) = Total Energy ekWh/yr [ ]

8 Total Energy ekWh/yr [ ] (Line 7) ÷ Total House Area ft^2 [ ] = BEPI ekWh/yr/ft^2 [ ] (Note 10)

BUILDING DIMENSIONS AND AREAS

1. **CAUTION!** You may work in metric units (metres and square metres) but please be sure to convert to imperial units (feet and square feet) before you enter the figures in the boxes.

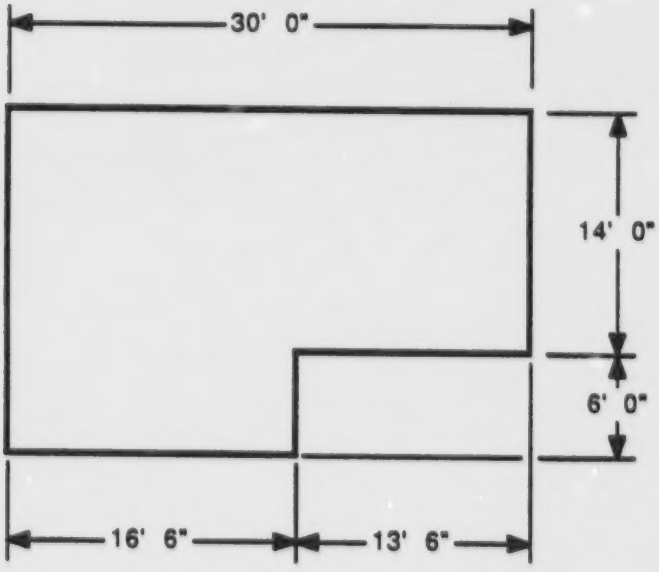
1 Metre	= 3.28 ft.
1 square meter	= 10.764 square feet

2. BUILDING FLOOR AREAS

You must measure the total enclosed heated floor area of the house. This is used to derive the BEPI and OEU. Measure to the outsides of the walls and include all heated spaces.

Measure your building and sketch in on the squared paper on page 8. The following example illustrates the procedure recommended.

Divide the area of each floor into rectangles.
Add together the area of all rectangles.
Subtract the area of any indentations.



PLAN

Floor Area	Sq. ft.
14.0 x 30.0	420.0
6.0 x 16.5	99.0
	519.0

Multiply by number of similar floors
Repeat calculation for dissimilar floors

3. BUILDING SKIN AREAS

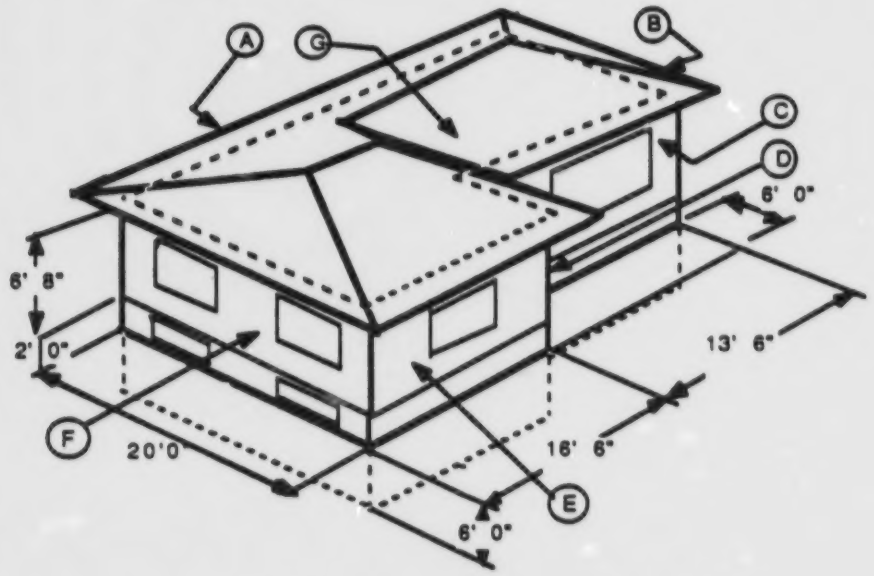
Analysis of the building skin determines the energy required for space heating. For semi-detached and row houses it is important to consider only the walls, floors, etc. that are exposed to the exterior and not to any adjoining house.

What is required are total areas of:

* walls (above-grade, including foundation wall, and below grade)
* roof and/or ceiling
* exposed floors
* single glazing (including frames)
* double glazed (including frames
* triple glazing (including frames)

Glazing includes both windows and doors.

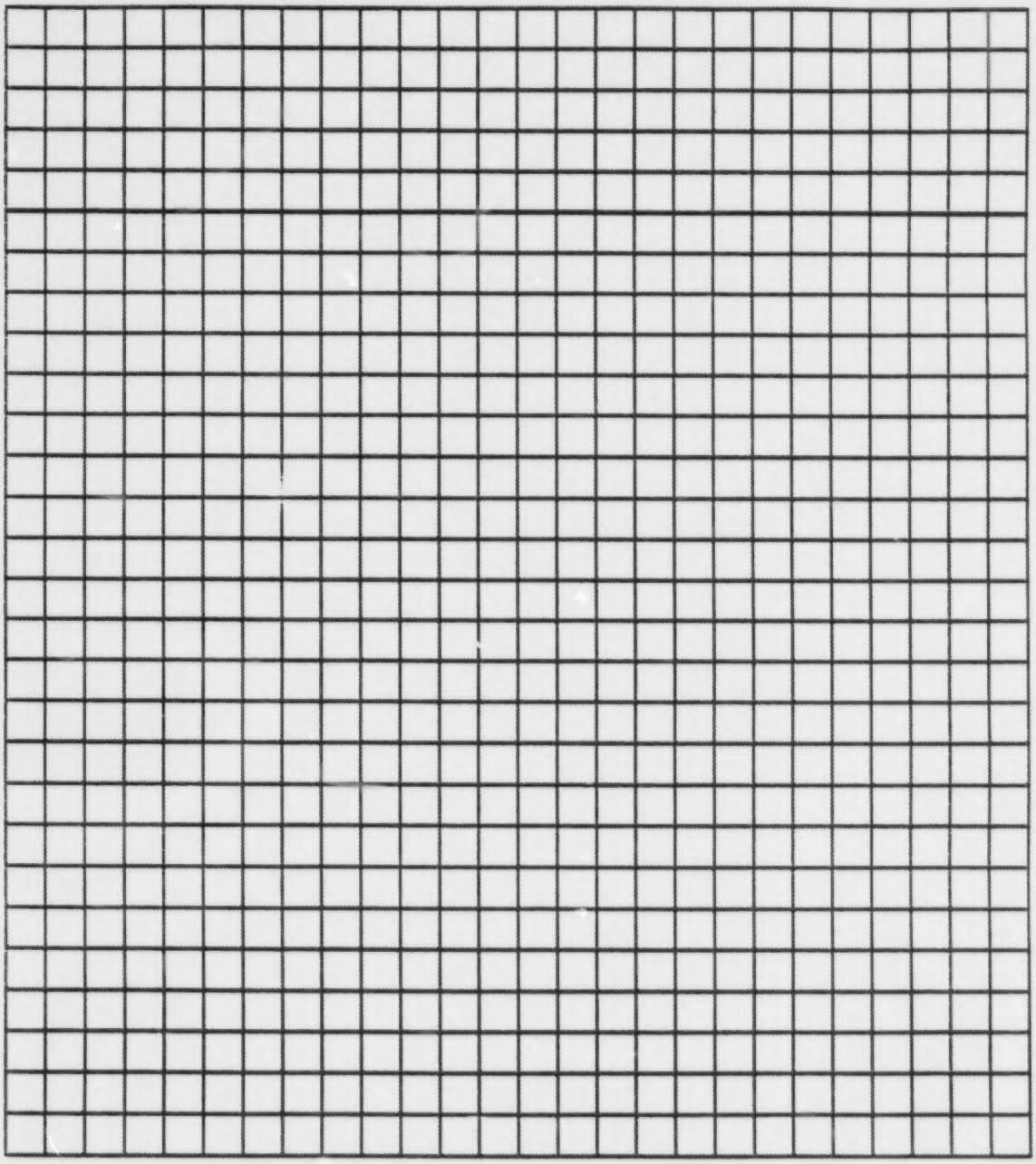
Again, take an organized and systematic approach to your measurement, as illustrated below. Use page 9 to sketch your building



AREAS (ft^2)

COMPONENT	A	B	C	D	E	F	G	H	TOTALS
Walls (above-gr, excluding fnd)	200.00	96.67	90.00	40.00	110.00	133.33			670.00
Walls (above-gr fnd)	60.00	28.00	27.00	12.00	33.00	40.00			200.00
Walls (Below gr)	180.00	84.00	81.00	36.00	99.00	120.00			600.00
Ceiling							519.00		519.00
Windows	36.00	12.00	15.00	0.00	12.00	24.00			99.00
Basement Floor								519.00	519.00

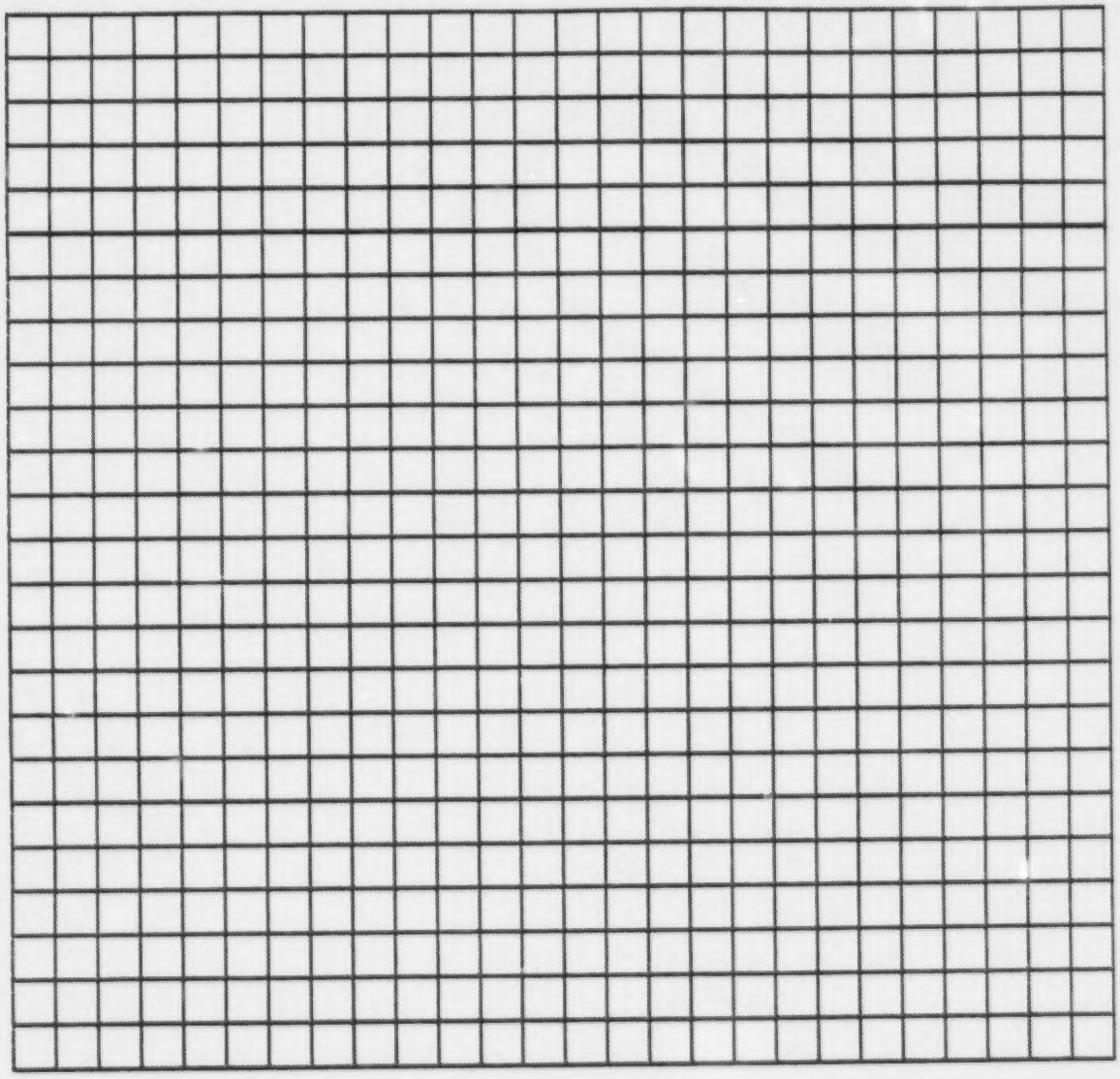
BUILDING FLOOR AREA CALCULATION



Total house floor area (Page 6, Note 2) _____ sq. ft.

(Note: 10.76 sq.ft. = 1 sq.m.)

BUILDING SKIN AREAS CALCULATION



(Page 7, Note 3)

		sq. ft.			sq. ft
1	Single Glazing		5	Floor exposed to ouside	
2	Double Glazing		6	Roof/Ceiling	
3	Triple Glazing		7	Basement wall below grade	
4	Net Wall Area (excl Glass Area)		8	Basement Floor	

OPTIMUM ENERGY USAGE OF 'AS IS' HOUSE

1. Thermal characteristics of windows can be estimated be the number of layers of glass used, since the overall thermal resistance depends primarily on the number of air spaces involved. The total area of all windows is also required to calculate heat loss. **Formula 1.1**

2. The thermal resistance of a floor, wall and roof or ceiling will depend largely on the thickness of insulation installed within them. Determine the net area of the exterior walls of interest by measuring or estimating the total wall area and subtracting the total window area. For roofs, the ceiling area can be used and floor areas will be those over unheated crawl spaces. **Formula 1.2**

3. To determine the heat loss through the basement walls and floors, the overall heat transfer coefficient (U) and the area are required. **Formula 1.3**

   Although it can be argued that a basement is not maintained at as high a temperature as other parts of the house, any difference in indoor temperature is more than masked by the variation in soil temperature surrounding the below grade wall and floor.

   Soil temperature at grade level around a house will tend to be equal to the outside air temperature, but soil at the basement floor level will be considerably warmer. Soil itself provides a measure of insulation, because it provides a separation between the basement and the cold winter environment. Snow accumulation around the house adds further insulation. In most cases heat loss through the above grade portion of the basement walls is much greater than from the rest of the basement, and can be treated the same as the other exposed portions of the house envelope.

4. It is difficult to estimate the heat loss due to exhaust or infiltration since there is no easy way to determine the actual rate of ventilation. Measurements or estimates can be made of the leakage characteristics of the house envelope but without a knowledge of the pressure differences created by wind, stack effect or furnace and exhaust fans, rates of flow cannot be determined. The ventilation rate will depend primarily on the occupants. If the house feels stuffy or if undesirable odours are sensed due to cooking or other activities, the occupants may open windows or doors or turn on exhaust fans. Presumably, such measures will be continued until satisfactory conditions are attained.

The minimum rate of ventilation required to maintain acceptable indoor air quality for a household of five persons is 100 cubic feet per minute (50 Litre per second). This is calculated at 20 cubic feet per minute per person (10 Litre per second per person). Based on this rate, the heat loss through ventilation can be estimated. **Formula 1.4**

5. For a particular house the amount of heat required for space heating in winter will depend on the indoor-to-outdoor temperature difference and the length of time during which the temperature difference is experienced. This information is most easily assessed from the number of Degree-Days for the region, as determined from the weather records for that region.

   A Degree-Day occurs when the average outdoor temperature for one day is one degree below a certain level, 18°C or 65°F. The number of Degree-Days for a given day is the amount by which the daily average temperature was below 18°C or 65°F. The number of Degree Days in a year is the sum of the Degree-Days of all of the days when the average daily temperature was below 18°C or 65°F. The number of Degree-Days for a particular locality is usually an average for all the years for which weather records are available.

   Most houses are maintained at temperatures higher than 18°C or 65°F, but the Degree-Day concept is based on the assumption that heat from the sun, occupant activities, operation of appliances, will raise the temperature levels to 24°C or 75°F and that Degree-Days can be used to estimate the energy purchased and used exclusively for space heating.

OPTIMUM ENERGY USAGE OF 'AS IS' HOUSE

1. The calculations on this sheet develop optimum energy usage (OEU) for the house's space heating system. Space heating replaces heat loss by conduction and air infiltration through windows, exterior walls, ceiling/roof, basement walls and floors. Heating of ventilation air is also included.

2. Heat losses through walls, ceiling/roofs and basement walls depend on insulation quality.

   The following tables and formulas allow you to determine the heat loss that is attributable to the various house components.

1. **Window Heat Loss** = $\frac{A \times DD \times 24}{R \times 3413}$ kWh/yr (1.1)

   for Imp units, R = Resistance, hr-ft^2-F°/Btu, taken from Table 1, Pg. 13.
   A = Area, ft^2, taken from Lines 1, 2, or 3, Pg.9.

2. **Heat Loss through walls ceiling, floors** = $\frac{A \times DD \times 24}{R \times 3413}$ kWh/yr (1.2)

   for Imp units, R = Resistance, hr-ft^2-F°/Btu, taken from Table 2, Pg. 13.
   A = Area, ft^2, taken from Lines 4, 5, 6, Pg. 9.

3. **Basement Heat Loss (Walls and Floors)** = $\frac{U \times A \times DD \times 24}{3413}$ kWh/yr (1.3)

   for Imp units, U = Overall Heat Transfer Coefficient, Btu/hr-ft^2-F°, taken from Table 3 (walls), Table 4 (floor), Pg. 14.
   A = Area, ft^2, taken from Lines 7, 8, Pg. 9.

4. **Ventilation Loss** (Imp units) = $\frac{DD \times 108 \times 24}{3413}$ kWh/yr (1.4)

   Note for the above equations: DD = Total Heating Degree Days taken from Table 5, Pg. 15.

TABLE 1 Thermal Resistances For Glazings

	S.I. Units (RSI)	Imperial Units (R)
SINGLE GLAZING	0.15	1
DOUBLE GLAZING	0.30	2
TRIPLE GLAZING	0.50	3

TABLE 2 Thermal Resistances for Various Thickness of Insulation (including an uninsulated component, i.e., wall, ceiling etc)

	S.I. UNITS (RSI)	IMP. UNITS (R)
Uninsulated	0.7	4
25mm(1in)	1.0	6
50mm(2in)	1.7	10
75mm(3in)	2.4	14
90mm(3.5in)	2.8	16
125mm(5in)	3.7	21
130mm(5.5in)	3.8	22
150mm(6in)	4.4	25
175mm(7in)	5.1	29
200mm(8in)	5.8	33
225mm(9in)	6.5	37
250mm(10in)	7.2	41
275mm(11in)	7.9	45
300mm(12in)	8.6	49

TABLE 3 Average Overall Heat Transfer Coefficients (U) For Basement Walls

Depth Below Grade		Wall Uninsulated		Wall Insulated to a Depth of 2 ft below grade			
				R-5	R-0.88	R-10	R-1.76
ft	m	Btu/hr-ft2-F	W/m2-C	Btu/hr-ft2-F	W/m2-C	Btu/hr-ft2-F	W/m2-C
4	1.22	0.200	0.035	0.140	0.025	0.130	0.023
5	1.52	0.180	0.032	0.140	0.025	0.130	0.023
6	1.83	0.170	0.030	0.140	0.025	0.130	0.023
7	2.13	0.160	0.028	0.140	0.025	0.130	0.023

Depth Below Grade		Wall Insulated Over Full Inside Surface			
		R-5	R-0.88	R-10	R-1.76
ft	m	Btu/hr-ft2-F	W/m2-C	Btu/hr-ft2-F	W/m2-C
4	1.22	0.088	0.015	0.054	0.010
5	1.52	0.082	0.014	0.050	0.009
6	1.83	0.079	0.014	0.048	0.008
7	2.13	0.076	0.013	0.047	0.008

TABLE 4 Average Overall Heat Transfer Coefficients (U) For Uninsulated Basement Floors, 3 ft or More Below Grade

Wall Uninsulated		Wall Insulated to a Depth of 2 ft Below Grade		Wall Insulated Over Full Inside Surface	
Btu/hr-ft2-F	W/m2-C	Btu/hr-ft2-F	W/m2-C	Btu/hr-ft2-F	W/m2-C
0.025	0.004	0.036	0.006	0.045	0.008

TABLE 5 Degree Days

Location	Degree Days, °C		Degree Days, °F	
	Total Year	Total Heating	Total Year	Total Heating
Barrie	4575	4257	8235	7663
Hamilton	3592	3427	6465	6168
Kenora	5938	5560	10688	10008
London	4132	3904	7438	7027
Niagara Falls	3661	3510	6590	6318
North Bay	4990	4691	8982	8444
Ottawa	4596	4372	8273	7869
Peterborough	4592	4352	8265	7834
Port Hope	4044	3841	7279	6914
S. S. Marie	5120	4665	9216	8397
Sudbury	5451	5071	9812	9128
Thunder Bay	5673	5316	10211	9569
Timmins	6225	5686	11205	10235
Toronto	3646	3498	6563	6296
Wawa	5838	5248	10508	9446
Windsor	3622	3488	6520	6278

NOTE: 1. No. of degree days is an average for 30 years.

2. To obtain degree days Fahrenheit multiply values from Table by 1.80

3. Total heating degree days = Jan + Feb + Mar + Apr + 1/2 May + 1/2 Sep+ Oct + Nov + Dec

HEAT LOSS PER HOUSE COMPONENT

1. As you calculate the 'as is' component heat losses , carry them directly to the appropriate lines on page 22.

Component	From Pg. 12 Eqn #	Heat Loss kWh/yr	Carry to Pg. 22 Line #
1. Single Glazing	1.1		
2. Double Glazing	1.1		
3. Triple Glazing	1.1		
4. Total Glass			1
5. Walls	1.2		2
6. Roof/Ceiling	1.2		3
7. Exposed Floor to Outside	1.2		4
8. Basement Wall	1.3		5
9. Basement Flr	1.3		6
10. Ventilation	1.4		7

OPTIMUM ENERGY USAGE FOR DHW HEATING

1. This section can be be used only if there are reliable fuel consumption figures on page 5 for the months of June, July, and August.

2. The principle is that fuel used in June, July, and August when space heating systems are off, indicates energy use for the year round DHW heating system. In an all electric house the value generated in line 3 includes electricity used for lighting, appliances, etc and is assumed to be constant throughout the year. A comparison to the DHW heater optimum energy use listed in line 4 does not apply to an all electric house.

3. You need to know the number of days in the June, July, August billing periods.
   From page 3:

   June reading date (start of period) _____
   August reading date (end of period) _____
   Total number of days _____

   Enter this figure in line 1.

4. Annual energy use for year round DHW heating is estimated on line 3.

5. The optimum energy usage for the DHW heater is estimated on line 4.

6. Transfer the value from line 3 to line 10 page 22.

7. If the actual energy usage is greater than the optimum energy usage specified in line 4 then an assessment as to the probable cause is required. Low and high DHW heating energy usage is also provided for comparison purposes. The increased DHW fuel consumption may be a result of one or more of the following:
   1. The number of occupants in the house is more than 5. The optimum energy usage is based upon an average family size (5 occupants).
   2. The DHW temperature setting may be on High rather than Normal or Low.
   3. The combustion efficiency of the DHW may be low. This can be easily determined by a steady state combustion efficiency test. The heater may need servicing and/or cleaning, or replacing.

OPTIMUM ENERGY USAGE FOR DHW HEATING

1. Total number of days in June, July and August

Total days [ ]

2. Total gas or oil in June, July and August billing periods from page 5.

June		July		August		Summer Fuel
[ ]	+	[ ]	+	[ ]	=	[ ]

3. Projected annual energy units for year round DHW heating system.

	Summer days		Summer Fuel		Projected Annual Fuel Use
365 ÷	[ ]	x	[ ]	=	[ ]
	Line 1		Line 2		

Projected Annual Fuel Use		Fuel Factor		Projected Annual Energy Units
[ ]	x	[ ]	=	[ ]
Line 3		Pg. 3 Note 6		ekWh/yr

4. Optimum energy usage for year round heating based upon average DHW heater use and a DHW seasonal efficiency of 55% is **8,600** kWh/yr.
   Excessive DHW energy use is estimated at **13,200** kWh/yr.
   Low DHW energy use is estimated at **4,000** kWh/yr.

OPTIMUM ENERGY USAGE AND POTENTIAL SAVINGS CALCULATIONS

1 Take great care to allocate the energy usage for each component to the correct utility - either fuel (oil or gas) or electricity.

Begin by crossing through all the boxes which do not apply to your house.

2 Enter all the optimum energy usages in lines 1-7 from the pages and lines referred to in col. 1.

3. Combustion factors allow for energy lost up the chimney when gas or oil is burnt in a furnace. Where an energy system is fuel heated, enter an appropriate combustion factor in its line. The factor is the inverse of the best seasonal efficiency to be expected of the equipment in use. Suggested values are:

Furnace Type	Seasonal Efficiency	Combustion Factor
Conventional		
15 years old	50%	2.0
New (continuous pilot)	55%	1.8
New (spark ignition)	60%	1.7
Mid Efficiency	75%	1.3
High Efficiency	89%	1.1

4 Complete the arithmetic for each line as indicated.

If the system is fuel heated, divide the the fuel usage in column 3 by the house floor area in column 2 and multiply this value by the combustion factor in column 5 to derive the optimum energy usage in column 6. If the system is electrically heated then divide the electricity usage in column 4 by the house area in column 2 and transfer this value directly to column 6.

Adds lines 1-7 in column 6 to get the total space heating component (OEU) on line 8.

Subtract line 10, DHW heating energy use, from line 9 to get the Actual Space Heating energy, on line 11.

Subtract the OEU on line 8, column 6 from the Actual Space Heating energy usage on line 11 to find the Potential Savings (line 12)

Multiply the potential energy savings on line 12 by the average energy unit cost on line 13 to find the Value of Potential Savings. This is the amount of money you could save.

Finally, divide the energy usages in column 6 by the total energy in column 6 line 8 and multiply by 100 to get the component percentage of the total energy usage in column 7. Divide the component areas in column 8 by the sum of the component areas and multiply by 100 to get the component percentage of the total skin area in column 9.

5. If the actual energy usage is within ±15% of the house's optimum energy usage then the house is using energy as efficiently as possible. If the difference is greater than +15% then the inefficiency is a result of increased heat loss due to air infiltration/exfiltration or unusual occupant behaviour. This conclusion is a based upon the fact that the ventilation component of the house heat losses is the minimum that is required by ASHRAE Standard 62-81 and the R-2000 Home Program. The other inputs in the heat loss analysis were based upon the actual house construction. Therefore an increased heat loss is indicative of increased air infiltration/exfiltration or an unreasonably high thermostat set point (greater than 24 °C or 75 °F). The increased air infiltration/exfiltration can either be attributed to high air leakage that results from the lack of weatherstripping, caulking, etc. or occupant lifestyle, i.e., opening of windows and doors.

   You must now decide which of the above is the cause. An inspection of the house will identify the condition of the weatherstripping, caulking, and general air tightness of the house skin. If it is apparent that upgrading is required then appropriate air sealing measures should be implemented. If the house is reasonably tight (as compared to other similar houses) then the problem may be occupant related. This requires some investigation. If the occupants are not the cause then an air leakage test (Blower Door Test) can be performed to assess the tightness of the house. A result of approximately 5 air changes per hour (ac/h) at 50 Pa is what an an average conventional home would measure. Older homes can range from 6 - 10 ac/h and R-2000 homes 1.5 ac/h at 50 Pa. The test will readily determine the sources of air leakage.

6. To identify components that could be upgraded a comparison can be made of the percentage of heat loss per component to the percentage that the component represents of the total skin area. If the percentage heat loss in column 7 is considerably more than its percentage area in column 9 then you should consider an energy conservation measure. To assess the potential savings, the increased insulation levels (R and RSI values) that are implemented can be introduced into equations 1.1 to 1.3 and the procedure described above repeated.

7. The following climate conversion factors should be utilized to normalize the space heating energy usage and thus relate the OEU's of the houses located in the various parts of Ontario. The factors normalize the OEU with the Toronto area serving as the base comparison.

Climate Conversion Factors

Location	Climate Conversion Factor
1. Hamilton	1.104
2. Kingston	1.170
3. Kitchener	1.179
4. London	1.133
5. North Bay	1.460
6. Orillia	1.280
7. Oshawa	1.080
8. Ottawa	1.280
9. Peterborough	1.250
10. Sarnia	1.065
11. Sault Ste. Marie	1.400
12.Sudbury	1.490
13. Thunder Bay	1.580
14. Timmins	1.700
15. Toronto	1.000
16. Welland	1.023
17. Windsor	0.990

Enter the factor in column 10 and recalculate the normalized energy usage in column 11 by dividing the value in column 6 by the conversion factor.

OPTIMUM ENERGY USAGE AND POTENTIAL SAVINGS CALCULATIONS

Column #	1	2	3	4	5	6	7	8	9	10	11
House Component	Ref. Page/ Line#	Floor Area ft^2	Fuel Usage ekWh/yr	Electricity Usage kWh/yr	Combust. Factor	Energy Usage ekWh/ft^2/yr	% of Total Energy	Comp. Area ft^2	% of Total Skin Area	Climate Conver. Factor	Energy Usage ekWh/ft^2/yr
1. Glass Heat Loss	16/4										
2. Wall Heat Loss	16/5										
3. Roof/Ceiling Heat Loss	16/6										
4. Exposed Floor Heat Loss	16/7										
5. Basement Walls Heat Loss	16/8										
6. Basement Floor Heat Loss	16/9										
7. Ventilation Heat Loss	16/10							———	———		
8. Total Space Heating (OEU)	———							———	———		
9. Total Actual Energy	5/3 or 4				———			———	———		
10. DHW Heating	18/3				———		———	———	———	———	———
11. Actual Space Heating = (Total Actual - DHW)	———				———		———	———	———	———	———
12. Potential Savings = (Actual Space - OEU)	———				———		———	———	———	———	———
13. Average Energy Unit Cost	5/5 or 6		$	$	———	$	———	———	———	———	———
14. Value of Potential Savings	———		$	$	———	$	———	———	———	———	———

HOUSE CHECKLIST

Note: Fill in the spaces and cross out inapplicable items.

Name of Occupant _____ No. of Occupants _____

Address _____ No. of Bedrooms _____

City _____ Move-in Date _____

Postal Code _____ Telephone _____

Type of House	Stories			
	Detached	1	1 1/2	2
	Semi-Detached	1	1 1/2	2
	Row	1	1 1/2	2

House's Year of Construction [ ]

Space Heating System	Forced Air	Baseboard	Hot Water		
Energy Source	Natural Gas	Electricity	Oil	Propane	Solar Panel
Domestic Hot Water	Natural Gas	Electric	Oil	Propane	Solar Panel

Furnace Information		
	Model/Type	
	Rated Output (Btu/h)	
	Rated Input (Btu/h)	
	Date of Last Maintenance	
	Steady State Efficiency	

DHW Information		
	Model/Type	
	Capacity (Imp. Gal) (L)	
	Rated Input (Btu/h) (Watts)	
	Date of Last Maintenance	
	Steady State Efficiency	

Mechanical Ventilation	Kitchen Fan/Use	Bathroom Fans/Use

		AREA	INSULATION THICKNESS	INSULATION TYPE
Ceiling	Area 1			
	Area 2			
	Area 3			
Exposed Fdn Wall				
Above Grade Walls	Area 1			
	Area 2			
	Area 3			

NOTE: Refer to and indicate area locations on the sketches on pages 8 and 9.

HOUSE CHECKLIST

Crawl Space

		AREA	INSULATION THICKNESS	INSULATION TYPE
Heated	Insulated at Floor			
Unheated	Insulated at Walls			

Slab-On-Grade

	AREA	INSULATION THICKNESS	INSULATION TYPE
Insulated			
Uninsulated			

	NORTH		EAST		SOUTH		WEST	
	Area	GL	Area	GL	Area	GL	Area	GL
Window Area 1								
2								
GL = No. of 3								
panes 4								

Outdoor Temperature ☐ F° ☐ C° Indoor Relative ☐

Indoor Temperature ☐ F° ☐ C° Humidity %

Thermostat ☐ regular ☐ temperature limiting

Thermostat Setting ☐ F° ☐ C°

	YES	NO
Staining, mould and mildew on walls		
Dust markings on walls		
Window Condensation		
on inside of interior pane		
between panes of sealed units		
Drafty		
Unusual odours or stuffiness		
Open doors, windows during winter		
Portable heaters utilized		

OBSERVATIONS/COMMENTS

2.1 ENERGY CONSERVATION MEASURES (ECM's) - SUMMARY

	ECM	Implementation	Resources for Assistance	Simple Payback	Comments
1.	North Niagara Energy Usage Monitoring System (EUMS)	Implementation requires installation and maintenance of computer and database.	North Niagara Housing Authority	3 years	Presently used by the North Niagara Housing Authority and has been successful in reducing energy consumption.
2.	Maintenance and Upgrading of Furnaces and DHW Heaters	Regular maintenance or the upgrading of conventional natural gas furnaces to mid efficiency units.	Local utility, heating contractor.	4 years	Downsizing of present furnaces after the implementation of ECM's should be considered as part of maintenance program
3.	Insulating Above Grade Fdn Wall and Header Area	Interior application of insulation, air tightening measures and vapour barrier at the header area and foundation wall.	Insulation contractor	For electric space heating = 11 years For natural gas space heating = 22 yrs. Retrofit of header area only - payback in 5 - 6 years.	Exterior application of insulation is warranted only if weeping tiles and/or foundation wall waterproofing required.
4.	Tightening the House Envelope	Implement in conjunction with an exterior wall retrofit.	Contractors with expertise in air tightening of buildings	From 7 to 16 years	No tightening is required in houses with an ELA (at 10 Pa.) less than 155 in^2. Electrically heated houses should have a bathroom or exhaust fan installed to operate fan in cold weather.
5.	Insulation Retrofit of Frame Walls	Implement at exterior in conjunction with upgrading of exterior wall cladding.	Insulation contractor	For electric space heating = 25 years For natural gas space heating = 50 yrs If existing wall uninsulated then payback = 5 - 6 years.	Application of insulation will require the addition of a vapour barrier. This may be satisfied with a suitable interior paint as specified in Part 11 of the OBC.
6.	Replacement of Windows	Implement in conjunction with exterior wall retrofit.	Rehabilitation Contractor	For electric space heating =12 years For natural gas space heating = 24 yrs	
7.	Centralized Air-to-Air Heat Exchangers	Implement in electrically heated row houses.	HVAC contractor	14 years	Heat exchangers are kept external to the row houses.

ECM #1

NORTH NIAGARA ENERGY USAGE MONITORING SYSTEM (EUMS)

Where the Measure Applies

This measure applies to all houses in the OHC stock.

Purpose of the Measure

The purpose of the measure is to reduce energy consumption that results from occupant lifestyle, e.g. opening windows and doors, high thermostat set point.

Description of the Measure

EUMS was developed by the North Niagara Housing Authority to assist it in the monitoring of natural gas and electricity consumption. The system monitors individual house consumption and allows for the comparison of one house to other houses in the project or to a similar house in another project. Comparison can also be made on an overall project to project level. The system establishes a useful energy consumption database.

Each house with high energy consumption is sent a letter recommending ways to decrease their individual consumption. Houses with low energy consumption are sent congratulatory letters.

This system essentially works to modify occupant behaviour.

Implementation

The system should be implemented in all Housing Authorities to monitor natural gas and electricity consumption. The computing system requirements are:

1. An IBM PC compatible computer with 640 KB RAM, one 360 KB floppy disk drive and a 10 MB hard drive.
2. dBase III plus or dBase III
3. Wordperfect or Wordstar with Mailmerge

The housing units requirements are:

1. Each housing unit must be individually metered.
2. Energy consumption for each housing unit must be read on a monthly basis.

The administration preparation requirements are:

1. Contact the Gas and Hydro company to arrange having meters read each month.
2. Prepare project information including the Project number, description, take over date of project and bedroom count breakdown.
3. Prepare unit information including Project number, Unit number, mailing address, number of bedrooms, and furnace information.
4. Prepare tenant information including Surname and total number of occupants in each unit and move-in date.
5. Assemble all gas and/or Hydro bills
6. Maintain system on a monthly basis, which requires the input of monthly gas and Hydro bills.

Payback Calculation

Based upon the implementation costs of the system in the North Niagara Housing Authority (NNHA), a payback of less than 3 years seems realistic. The NNHA saved $15,000 in the first 8 months of operation; by the end of the second year the capital costs had been returned. The payback period will vary for each H.A. depending on the housing stock size since the larger H.A. will require greater computer and software start-up and maintenance costs.

ECM #2

MAINTENANCE AND UPGRADING OF FURNACES AND DHW HEATERS

Where the Measure Applies

This measure applies to all detached, semi-detached and row houses that have gas fired furnaces and DHW heaters.

Purpose of the Measure

The purpose of the measure is to reduce energy consumption that results from inefficient furnaces and DHW heaters.

Description of the Measure

The measure requires that all DHW heaters be cleaned on a regular basis. As well, the temperature setting on DHW heaters should be set at Normal or as low as possible. Furnaces should be included in a regular maintenance program where the following components are replaced or serviced:

1. replace filters monthly during the heating season
2. clean burner
3. inspect and clean heat exchanger
4. adjust fan belts if necessary
5. clean fan blades
6. oil the furnace motor

Implementation

If the actual energy usage is high and the cause is not related to occupant lifestyle or infiltration, and upon visual inspection of the house it is determined that the furnace and/or DHW is contributing to the excessive energy use then a combustion analysis of the equipment may be warranted to assess their steady-state combustion efficiency. If the steady state efficiency is below 70% then the units may need cleaning or adjusting as discussed above.

If the heating system is in poor shape and/or has less than 5 years life expectancy then replacement with a new furnace may be necessary. Furnaces (heat exchangers) have a life expectancy of approximately 20 years. If this is the case and the old furnace is a conventional type, then replacement with a mid efficiency furnace is warranted. A 15 year old conventional furnace has a seasonal efficiency of approximately 50% while a mid efficiency furnace has an average efficiency of approximately 75%.

Many furnaces are oversized. Ideally, the furnace should be sized so that it fires constantly during periods of peak heating demand. An oversized furnace cycles frequently, and the amount of heat that is lost up the chimney during off-periods when the furnace cools increases the seasonal efficiency of the furnace. The service technician should assess the potential for downsizing as part of the servicing program. This should be considered after ECM's have been implemented as fuel use will then decline and the existing furnace seasonal efficiency will decrease.

Payback Calculation

The upgrading to a mid efficiency furnace can account for up to a 25% reduction in fuel consumption. The simple payback for the upgrading of a conventional furnace to a mid efficiency furnace is approximately 4 years, according to the 1988 report by the Ontario Ministry of Housing on the replacement of gas furnaces.

ECM #3

INSULATING ABOVE GRADE FOUNDATION WALL AND HEADER AREA

Where the Measure Applies

This measure applies to all detached, semi-detached and row houses that have uninsulated above-grade foundation walls and header area (the junction of the floor joists and the exterior trim joist).

Purpose of the Measure

The purpose of the measure is to reduce heat loss through the header and above-grade portion of the foundation wall.

Description of the Measure

Heat loss occurs through the header area and the above-grade portion of the foundation wall. In order to reduce heat loss these areas must be insulated. A vapour barrier must be applied at the warm side of the insulation and sealing at the sill/foundation wall, header/sill and header/subfloor interfaces to minimize condensation due to exfiltrating air and diffusion of water vapour.

Implementation

Any house that does not have an insulated header area and/or above-grade portion of the foundation should be insulated. These areas account for a disproportionate amount of the heat loss through the house envelope. The insulation can be applied to the exterior or interior of the foundation wall. However, based upon a previous report "Insulation Retrofit of Concrete Block Basements" by Morrison Hershfield Limited in 1984, the most cost-effective method would be the installation of the insulation at the interior using glass fiber batt insulation. The Ontario Building Code (OBC) requires a minimum thermal resistance of RSI 1.41 (R 8) for new construction. An exterior application would be warranted only if such work as installation and repair of weeping tiles and/or foundation waterproofing was required.

When insulating the header area it can become awkward where the joists run parallel to the foundation wall. In this case a polyurethane foam should be used.

Payback Calculation

Exterior insulation of exposed basement walls for house in Peterborough - 4352 Degree Days

2 feet height of basement wall is exposed

Perimeter of the house = 2 x (length + width)
= 2 x (20 + 30)
= 100 ft

Area of basement wall = 2 ft x 100 ft
= 200 ft^2

Cost of insulation is 40 ¢/ft^2, finish is 30 ¢/ft^2

Material Cost = 200 ft^2 x (.4 + .3) = $140.00

Labour $300.00

Total $440.00

Before upgrading Heat Loss: R value = 5.8

Using equation 1.2

$$\text{Heat Loss} = \frac{200\ ft2 \times 4352\ DD \times 24 \times .06}{5.8 \times 3413}\ ¢/kWh = \$65.00$$

After upgrading with 2 inches of insulation in place: R value = 13.7

$$\text{Heat Loss} = \frac{200 \times 4352 \times 24 \times .06}{13.7 \times 3413}\ ¢/kWh = \$25.00$$

Saving = $65.00 - $25.00 = $40.00

Simple Payback = $\frac{440.00}{40.00}$ = 11 years for electric space heating

for natural gas heating the simple payback = 22 years.

Note: electric space heating cost = 6 ¢/kWh
natural gas space heating cost = 3 ¢/kWh

According to the 1984 studies conducted by Morrison Hershfield on the insulation and retrofit of concrete block and cast-in-place concrete basements the simple payback for the installation of glass fiber insulation on the interior of a house was in the range 6 - 7 years for retrofit of a concrete block basement and 16 - 17 years for retrofit of a cast-in-place concrete basement. The retrofit of the header area only results in a simple payback of 5 to 6 years.

ECM #4
TIGHTENING THE HOUSE ENVELOPE

Where the Measure Applies
This measure applies to all detached, semi-detached and row houses.

Purpose of the Measure
The purpose of the measure is to reduce heat loss due to infiltration/exfiltration.

Description of the Measure
Heat loss occurs due to the infiltration of exterior air and the exfiltration of house air. Energy must be expended to heat the air that is entering a house, from the outside temperature to room temperature. If the house is humidified, energy must also be input to humidify the outside air.

In order to reduce infiltrating air there must be a reduction in the number of openings in the house envelope. It involves the exterior weatherstripping and caulking of all houses around windows, doors. As well, interior sealing is required at exterior wall outlets/switches, plumbing holes in walls and floors, all floor mouldings, ceiling light fixtures, attic access and hatch doors and dryer vents.

Implementation
If the Optimum Energy Usage of a house differs from the actual space heating energy consumption and the problem is not occupant related, then the air tightness of the house should be assessed. An inspection of the house will identify any openings such as open dryer vents and the condition of the existing weatherstripping and caulking. If the problem is apparent then remedial measures should be taken. If not, then a Blower Door Test can be performed. The test is quick and easy to perform and measures the air leakage of a house at a standard pressure differential. While conducting the test it becomes apparent where the major openings in the envelope are located. Remedial measures can then be taken .

The test was performed in general accordance with CGSB Standard CAN2-149.10-M85, "Determination of the Airtightness of a Building Envelope by the Fan Depressurization Method", with one modification. During the test, all intentional openings were left in their normal condition. To perform a Blower Door Test (air tightness test) a portable, speed-controlled fan is temporarily mounted in a doorway and used to lower indoor air pressures by exhausting large quantities of air from the house. Pressure differences across the envelope are established in the range of ten to sixty Pascals and the air flow quantities required to sustain these differences are recorded. A series

of flow and pressure readings are required to determine the rate at which air flow increases with pressure difference.

It must be noted that increasing the tightness of a house may result in increased humidity levels that may cause condensation problems. It is therefore necessary to consider the following recommendations given in the 1984 report "The Weatherize Project" by Sebastian Moffatt, Sheltair Scientific Limited:

1. In houses already experiencing indoor related moisture problems, an investigation should be made to determine the cause before tightening occurs.
2. Humidifiers should be disconnected when houses are tightened.
3. Electrically heated homes should have a bathroom or exhaust fan installed with a humidistat control to operate the fan in cold weather.
4. Tightening should not be implemented in houses where the Equivalent Leakage Area (ELA at 10 Pa.) is less than 155 in^2 (1000 cm^2). The blower door test in this case requires all intentional openings, i.e., chimneys, exhaust fans or ducts, be sealed.

Payback Calculation

The payback of tightening the house envelope depends on the age of the house. Older houses require more work than newer ones. However, based upon the above-mentioned study, the average amount of time required to provide comprehensive air sealing was 3 person-days per house. Material costs averaged $200.00. The average fuel reduction was measured to be 10.4% for the houses that recorded a reduction in fuel consumption.

Average fuel cost = $675.00 per house
Space heating = 2/3 of total cost = $450.00 per house.

Material Cost = $200.00
Labour = $360.00
Total = $560.00

Fuel Savings = 10.4%
= .104 x 450
= $46.80

Simple Payback = $\frac{560.00}{46.80}$ = 11.97 years

In the above-mentioned study it was noted that the reduction in fuel consumption was difficult to measure. In several cases houses used more fuel after tightening indicating the possible effects of occupant lifestyle. However, the potential savings in fuel consumption can range from 7 to 16 % resulting in simple paybacks of 6.9 to 15.9 years.

ECM #5
INSULATION RETROFIT OF FRAME WALLS

Where the Measure Applies

Based upon the 1983 report "Insulation Retrofit - Frame Walls in Houses" prepared by Scanada Consultants Limited, there were approximately 450 single family and semi detached housing units built prior to 1961 that had uninsulated frame walls. Not all of these homes have been retrofitted as was evident in the housing inspections conducted in the fall of 1988 by Trow Inc. This measure applies to all OHC stock that have little or no insulation in the above-grade frame walls. This ECM would generally apply to houses built prior to 1972, with the majority of houses with no insulation built prior to 1961.

Purpose of the Measure

The purpose of the measure is to reduce heat loss through frame walls.

Description of the Measure

This measure would require that the remaining uninsulated houses be retrofitted. This would involve the addition of insulation from either the inside or the outside, as well as the addition of a vapour barrier on the warm side of the insulation.

Implementation

If possible the installation of insulation in a house should be conducted from the exterior of the house. Reasons for this were sited in the 1983 Scanada report referenced above and are as follows:

1. Many housing units are relatively small; consequently contractors have difficulty maneuvering resulting in inconvenience to the tenants and substantial moving of interior furniture.
2. Interior installation results in dust and dirt created by drilling, blowing, patching and sanding of the holes. As well, the interior surface requires painting.

The installation of insulation should accompany the upgrading of exterior cladding. This means that even if a house has the minimum required thermal resistance of RSI 2.11 (R 12) the retrofit should be implemented. In this case an insulating sheathing should be used consisting of an exterior rigid insulation that has a surface material resistant to air flow. This would increase the thermal resistance of the wall and reduce air infiltration/exfiltration.

The installation of insulation requires that a vapour barrier be in place on the warm side of the insulation. This requirement can be fulfilled by a suitable application of interior paint, as specified in Part 11 of the OBC, or if the insulation is applied from the exterior, and 2/3 of the total RSI value is located at the exterior, then the vapour barrier can be applied atop the old exterior siding.

Air tightening of the house envelope, as described in ECM #4, should be implemented in conjunction with the installation of insulation if an interior application is conducted.

Payback Calculation

1. Based upon the 1983 report,Insulation Retrofit of Frame Walls in Houses, by Scanada Consultants Limited, the simple payback for the insulating of existing uninsulated frame walls is 5 to 6 years.

2. Exterior Wall insulation/Cladding (if cladding replacement warranted)
Use Peterborough 4352 Heating Degree days.

Perimeter of the house = 2 x (length + width)
= 2 x (20 + 30)
= 100 ft

Wall area = 8 ft x 100 ft = 800 ft^2
Cost of insulation is 80 ¢/ft^2, labour is 40 ¢/ft^2
Retrofit cost = 800 ft^2 x 1.20 \$/ft^2
= \$960.00 for insulating wall cavity.

Before upgrading Heat Loss: R value = 14

Using equation 1.2

$$\text{Heat Loss} = \frac{800\ ft2 \times 4352\ DD \times 24 \times .06}{14 \times 3413} = \$104.92$$

After upgrading Heat Loss: R value - 21.9

$$\text{Heat Loss} = \frac{800 \times 4352 \times 24 \times .06}{21.9 \times 3413} = \$67.07$$

Saving = \$104.92 - \$67.07 = \$37.84

$$\text{Simple Payback} = \frac{\$960.00}{37.84} = 25.4 \text{ years}$$

for electric space heating
for natural gas heating the simple payback = 50 years

Note: electric space heating cost = 6 ¢/kWh
natural gas space heating cost = 3 ¢/kWh

ECM #6
REPLACEMENT OF WINDOWS

Where the Measure Applies

This measure applies to all detached, semi-detached and row houses that have single pane horizontal sashless sliders or single pane vertical sliders.

Purpose of the Measure

The purpose of the measure is to reduce heat loss through windows that occurs primarily as a result of air infiltration/exfiltration.

Description of the Measure

At the present time many of the older homes (pre 1970) in the OHC stock have windows that consist of single pane horizontal sashless sliders or vertical single pane sliders. These windows are considered to be poor quality windows. Little or no weatherstripping is included in the window unit thereby allowing air to infiltrate/exfiltrate. This results in higher heat loss as well as condensation occurring on the faces of the outer and inner sliders of the unit that can lead to deterioration of wood frames and interior trim.

This measure requires that all units that have single pane horizontal sashless sliders or single pane double hung windows be replaced by horizontal double sliders fitted with aluminum frames and weatherstripping or that all single glazed windows be converted to double glazed windows by adding exterior storm windows. Similar retrofit should be applied to the vertical sliders.

A general principle to be followed in double glazing is to place the most air tight window on the inside. This reduces or prevents warm moist air from exfiltrating and condensing between window panes.

Implementation

These units should be replaced when any exterior retrofit is considered, e.g. the addition of exterior insulation and cladding.

Payback Calculation

Storm Window for a house in Peterborough, 4352 Heating Degree Days

Single glazed windows in basement

Total window area = 8 windows x 5 ft^2/window.= 40 ft^2

If one storm window is $60.00 installed, total for 8 windows is $480.00

Before upgrading Heat loss: R value = 1.0

Using equation 1.1

$$\text{Heat Loss} = \frac{40 \times 4352 \times 24 \times .06}{1.0 \times 3413}\ ¢/kWh = \$75.00$$

After upgrading with storm windows: R value = 2.0

$$\text{Heat Loss} = \frac{40\ ft2 \times 4352\ DD \times 24 \times .06}{2.0 \times 3413}\ ¢/kWh = \$35.00$$

Saving = $75.00 - $35.00 = $40.00

Simple payback = $\frac{\$480.00}{\$40.00}$ = 12 years for electric space heating

for natural gas heating the simple payback = 24 years

Note: electric space heating cost = 6 ¢/kWh
natural gas space heating cost = 3 ¢/kWh

ECM #7
CENTRALIZED AIR-TO-AIR HEAT EXCHANGERS

Where the Measure Applies
This measure applies to all row housing complexes.

Purpose of the Measure
The purpose of the measure is to reduce heat loss that occurs as a result of uncontrolled air infiltration/exfiltration, i.e., ventilation as a result of tenants opening windows.

Description of the Measure
The measure incorporates an air-to-air centralized heat exchanger that would supply the required quantity of ventilation air (as specified by ASHRAE Standard 62-81 and the R-2000 House Program) to the units in a row house complex. The measure would minimize or eliminate the need for tenants to open windows for ventilation purposes. It is important to understand that in many electrically heated row houses the quantity of ventilation air may be below the required quantity. This is a consequence of reduced ventilation that results from the absence of a chimney. If tenants reduce or eliminate the desire to open windows then energy is conserved in two ways:

1. Only the minimum required ventilation is supplied to the tenants. Therefore a minimum amount of energy is expended in heating incoming air.
2. By using a heat exchanger energy is conserved by the transfer of energy from the out going air to the incoming.

Implementation
The measure should be incorporated on all OHC row houses complexes. The air-to-air heat exchangers would be centralized and kept external to the row houses. This prevents tampering of the unit by tenants and facilitates servicing.

Payback Calculation
Separately housed central air-to-air heat exchanger for row housing block.
Assume 4 units in one block.

Space heating bill is $400.00. average per unit per year.
Heat loss due to ventilation systems constitutes 20% of heating bill = $80. unit/year
Efficiency of air-to-air heat exchanger = 70%
Each unit recovers $56.00
Total per 4 units = $224.00
Cost of Unit approximately $3,000.00

$$\text{Simple Payback} = \frac{\$3,000.00}{\$224.00} = 13.39 \text{ years}$$

2.2 ASSESSMENT OF THE RESULTS

In order to assess the effectiveness of the implemented ECM's, it is necessary to monitor the energy consumption in the houses after upgrading. The system developed by the North Niagara Housing Authority, the Energy Usage Monitoring System (EUMS), is recommended as the monitoring system to be employed. The houses selected in the field investigation as being the six worst energy users should be retrofitted with applicable ECM's and monitored.

The ECM most appropriate is the insulating of the foundation walls and header area since five of the six energy users were not insulated in these areas. In three of the six houses the occupants were responsible for the excessive energy use. The effective of the EUMS on occupant lifestyle in these houses can be determined.

It is also recommended that houses be selected for upgrading in the North Niagara Housing Authority Region. This would make monitoring of upgraded houses easy and cost effective since a database based on four years energy use is already in place. The selection of high energy using houses to be upgraded can be made by the EUMS.

2.3 ENERGY MANAGEMENT GLOSSARY

This glossary includes terms used in this manual as well as terminology frequently used in energy management.(Reference 6)

AIR CHANGES (AC or AC/HR) A way to express ventilation rates, which are the number of times the air volume of a given space will be replaced in a one hour period.

AMBIENT TEMPERATURE The temperature of the surrounding air.

ASHRAE American Society of Heating, Refrigerating and Air Conditioning Engineers.

ASHRAE Standard 90-75. Energy conservation "component performance" standards for new building design developed and adopted by ASHRAE in 1975.

BASE LOAD Energy loads which occur regardless of outside temperatures. (e.g., domestic hot water, laundry, kitchen equipment, etc.)

BRITISH THERMAL UNIT (Btu) A heat unit equal to the amount of heat required to raise one pound of water one degree Fahrenheit. (Btuh-Btu's per hour.)

BUILDING SHELL All external surfaces that are subject to climatic impact - for example walls, windows, roofs, and floors.

CAPACITY, THERMAL OR HEAT STORING The property of a material which determines the amount of heat or cooling it will absorb. It is a function of the mass of the material and its specific heat.

COMBUSTION EFFICIENCY A measure of the proportion of a heating fuel that is converted to useful heat energy. A furnace combustion efficiency of 80% means that 80% of each unit of heating fuel is converted to useful heat during the combustion process. The remaining 20% is lost in the form of hot exhaust gas from the combustion process and unburned fuel.

COMFORT ENVELOPE The area on a psychrometric chart enclosing all those conditions described in ASHRAE Standard 55-74 "Thermal Environmental Conditions for Human Occupancy", as being comfortable.

COMFORT ZONE (Average) The range of effective temperanures over which the majority (50 per cent or more) of adults feel comfortable, (extreme) the range of effective temperatures over which one or more adults feel comfortable (see Effective Temperanure).

CONDENSATE Water caused by changing the state of water vapour that is steam or moisture in air from a gas to a liquid; usually caused by cooling.

CONDENSER A heat exchanger that removes heat from a vapour, changing it to its liquid state. (In refrigeration systems, it is the component that rejects heat).

CONDUCTION A method by which heat is transferred through a material or between different materials, as a result of direct contact.

CONSUMPTION (energy) The total amount of energy used over a specific period of time, usually a month or a year. In the past the common unit of energy consumption for buildings was the Btu (British Thermal Unit). Now it is the Joule. Each energy source has its own unit of consumption for billing, which can be converted to joules. For electricity it is the kilowatt-hour, for gas it is the cubic metre, and for most fuels it is the litre or kilogram.

CONVECTION The transfer of heat by movement of a fluid (gas, vapour or liquid).

CONVECTION, FORCED Convection resulting from circulation of a fluid by a fan or pump.

COOLING LOAD Rate of heat removal necessary for maintaining a space at the desired temperature, usually offset by supplying air at a temperature below that which is desired. Heat is removed from the space as the supply air is warmed up to the space temperature.

DEGREE DAY, COOLING Similar to heating degree day, except measured in terms of average daily temperanure difference above 18 degrees C (65 degrees F). Not generally applicable for use in colder climates.

DEHUMIDIFICATION The condensation of water vapour from air by cooling below the dewpoint or removal of water vapour from air by chemical or physical methods.

DIURNAL TEMPERATURE RANGE The range of temperature occurring over a 24-hour time span.

EDGE LOSS The heat loss where the exterior walls of a building meet the ground floor slab.

EFFECTIVE TEMPERATURE An arbitrary index which combines into a single value the effect of temperature, humidity and air movement on the sensation of warmth or cold felt by the human body.

EFFICIENCY, OVERALL SYSTEM The ratio of the useful energy (at the point of use) to the thermal energy output for a designated time period, expressed in a percentage.

EMISSIVITY, THERMAL The capacity of a material to emit radiant energy. Emittance is the ratio of total radiant energy emitted by a body to that emitted by a "black body", (a perfect absorber of radiant heat that emits none) at the same temperature.

ENERGY The capacity for doing work. Different forms may be transformed from one type into another, such as thermal (heat), mechanical (work), electrical, and chemical. Energy is measured conventionally in kilowatt-hours (kWh) or British Thermal Units (BTU). Energy is measured in SI units in joules (j) where 1 joule = 1 watt second.

ENERGY ANALYSIS A comprehensive study of a building's energy use and costs to determine how much, when, why and where energy is used in the building. It will allow the energy planner to determine the feasibility of the opportunities identified by the energy audit as requiring further study and to identify and evaluate many new opportunities as well. It may also be used to determine energy code compliance since it includes a mathematical simulation of the building's energy use.

ENERGY AUDIT A specific accounting of the various forms of energy used during a designated period of time, usually annually. It aims at identifying the major opportunities for improving a building's energy performance through a short study of the building, its operation and use, its equipment, and its energy bills.

ENERGY BUDGET A design or consumption budget for a building or space use which is expressed in energy units that reflect the energy used to operate the various service systems.

ENERGY INDEX (EI) A reference that expresses the total energy (fossil fuel and electricity) used by a building in a given year, i.e., kWh/gross conditioned square foot/year.

EVAPORATOR A heat exchanger that adds heat to a liquid, changing it to a gaseous state. (In a refrigerator system, it is the component that absorbs heat.)

EXFILTRATION Indoor air leakage to the exterior through building envelope caused by a pressure differential.

GROSS FLOOR AREA The sum of the areas of the floors of the house -including basement. Gross floor area is measured from the exterior faces of exterior walls or from the centerline of walls separating buildings. Open roofed-over areas, porches, and similar spaces are excluded. The gross floor area does not include such features as exterior terraces, steps, chimneys, roof overhangings, etc.

GROSS WALL AREA The vertical projection of the exterior wall area bounding interior space that is conditioned by an energy-using system; includes opaque wall, window and door areas.

HEAT EXCHANGER A device used to transfer heat from a fluid flowing on one side of a barrier to a fluid flowing on the other side of the barrier.

HEAT GAIN The amount of heat gained by a space, and coming from all sources, including persons, lights, machines, sunshine, etc. The total heat gain represents the amount of heat that must be removed from a space in order to maintain indoor comfort conditions.

HEAT LOSS The sum cooling effect of the building structure when the outdoor temperature is lower than the desired indoor temperature. Heat loss represents the amount of heat that must be provided to a space in order to maintain indoor comfort conditions.

HEAT PUMP A refrigeration machine possessing the capability of reversing the flow, so that its output can be either heating or cooling. When used for heating, it extracts heat from a low temperature source and raises it to the point at which it can be used.

HEAT RECOVERY Heat utilized which would otherwise be wasted.

HEAT SINK A body (water, earth, metal, etc.) capable of accepting and storing heat. It can also serve as a heat source.

HEATING DEGREE DAYS The concept of heating degree days was derived in an attempt to correlate the heating fuel consumed by buildings with the outside temperature. The number of heating degree days recorded for a particular day is the difference between 18 degrees C (65 degrees F) and the average outdoor temperature for that day -if the outdoor temperature is less than 18 C (65 F). No attention is given to those days for which the average temperature is above 18 C (65 F).

For example: a day when the average temperature is 13 degrees C (55 degrees F) would result in 18 degrees C - 13 degrees C = 5 degrees C degree days (65-55 =10 degrees F degree days). A 29 degree C (75 degrees F) day would not have any heating degree days, because the temperature was not below 18 degrees C (65 degrees F).

HEATING LOAD The rate at which heat must be provided by the heating equipment to maintain indoor comfort conditions. This is seldom the same as the heat loss, since the building may have internal sources of heat gain which counteract some of the heat loss.

HUMIDITY (RELATIVE) A measurement indicating the moisture content of air. It is the ratio of the existing vapour pressure of the water in the air, to the vapour pressure of water in the air when it is saturated, at the same dry bulb temperature.

INFILTRATION The uncontrolled inward air leakage through cracks and interstices in any building element and around windows and doors of a building, caused by the pressure effects of wind and/or the effect of differences in the indoor and outdoor air density.

INSOLATION Solar radiation that arrives at the earth's surface.

INSULATION A material having a relatively high resistance to heat flow and used principally to retard the flow of heat. Four major classifications of building insulating materials are: 1) batt,

2) loose fill, 3) reflective, and 4) rigid.

KILOWATT (kW) Standard unit for measuring the rate of electrical energy use; thousands of watts.

KILOWATT-HOUR (kWh) Standard unit for electric energy consumption; the product of kilowatts x hours.

LIFE CYCLE COST The cost of the equipment or entire facility over its entire life - includes operating and maintenance costs.

LOAD PROFILE Time distribution of building's heating, cooling and electric load.

LUMEN Unit of luminous flux. A measure of lighting level.

MEGAJOULE Unit of power equal to 0.277 kilowatt hour or 1,000 joules.

MEGAWATT Unit of power equal to 1,000 kilowatts or 1 million watts.

MICROCLIMATE Climate at specific site as defined by local variations in the regional climate caused by topography, vegetation, soils, water conditions, as well as man-made construction.

NIGHT SET BACK A HVAC control strategy which maintains lower room temperatures during unoccupied periods in the heating session.

NON-RENEWABLE ENERGY A depleting energy source which is virtually impossible to recreate, such as the fossil fuels (c l, natural gas).

OUTSIDE AIR Air taken from the outdoors, and therefore not previously circulated through the system.

PASSIVE DESIGN METHODS Using building elements to accept, store, and distribute the flows of energy from nature (most often solar) to provide benefits to activities and processes within the building without the use of external power. If external power is required for distribution by fans or pumps it is called an "active" system.

PAYBACK PERIOD The amount of time it takes the savings resulting from a modification to "pay back" the costs involved. A "simple" payback period does not consider the time value of money; a discounted payback period does.

POWER The time rate of doing work, as applied to machines. In connection with the transmission of energy of all types, power refers to the rate at which energy is transmitted; in customary units, it is measured in watts (W) or British thermal units per hour (Btu/h).

PROCESS ENERGY Energy consumed in non-HVAC processes, such as in a laundry or a kitchen, or in the production of domestic hot water.

RADIATION Energy, in the form of electromagnetic waves, which is continually passing between the surfaces of all bodies.

RATE SCHEDULE The list of charges that the utility applies to its customers for the provision of energy.

RECOVERED ENERGY Energy, utilized from an energy utilization system, that would otherwise be wasted.

RENEWABLE ENERGY Sources of energy derived from incoming solar radiation and energy derived from the internal heat of the earth.

RESET Adjustment, automatic or manual, of the set point of a control instrument to a higher or lower value, for the purpose of conserving energy.

R-VALUE The resistance to heat flow. R = 1/U (See U-value).

RSI VALUE The metric equivalent of R-Value. RSI = 0.176 x R;

R = 5.68 X RSI.

SEASONAL EFFICIENCY A measure of furnace efficiency, including standby losses. Seasonal efficiency is always equal to or less than 100%. Seasonal efficiencies for gas-fired heating equipment range typically from 55 to 90%.

Electric boilers do not have combustion losses, but do have standby losses. The seasonal efficiency of electric boilers ranges typically from 90 to 95%.

TONS OF REFRIGERATION Terminology for expressing cooling capacity (ton = 12,000 Btu/h).

"U" VALUE A coefficient expressing the thermal conductance of a composite structure in Btu per (square foot) (hour) (degree F temperature difference).

VAPOUR BARRIER A moisture impervious layer designed to prevent moisture migration.